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ABSTRACT

The more than 100 papers in this collection describe examples of successful technology integration in teacher education. The applications are extremely diverse, including computer-assisted instruction, hypermedia, interactive video, computer simulations, telecommunications, and more. The applications also represent the range of instructional and learning theories. There are applications based on behavioral learning models, applications that express Piagetian developmental learning theory, computer applications based on learning styles research, and applications that articulate a cognitive science perspective. The reports also represent several levels of thought. There are many "how to" papers that provide detailed information on a variety of ways to use technology. Context papers address the big picture, such as the roles of technology in undergraduate education and the importance of general teaching strategies. Issue papers ask critical questions and propose some answers. Theory papers relate established and emerging general theories to the way technology is used. The papers are presented on 11 categories: (1) preservice teacher education (14 papers); (2) inservice and graduate education (3 papers); (3) hypermedia (11 papers); (4) telecommunications (11 papers); (5) science and mathematics (9 papers); (6) management (3 papers); (7) projects (6 papers); (8) simulations (4 papers); (9) issues (8 papers); (10) research (10 papers); and (11) theory (11 papers). Individual papers include references. (DB)

Society for Technology and Teacher Education

Technology and Teacher Education Annual 1991

General Editors
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Regan Carey
Dee Anna Willis
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PREFACE

This Technology and Teacher Education Annual 1991 is the product of both the time and the hard work of many teacher educators. The papers were selected by the National Planning Committee of the conference. The articles were edited by Section Editors, who were selected because of their knowledge and expertise, then compiled by the General Editors. The papers were presented at the Second Annual Technology and Teacher Education Conference, held in Greenville, North Carolina on April 25, 26, and 27 of 1991.

As a field, teacher education has lagged behind many other disciplines in higher education when it comes to integrating technology into the curriculum. In fact, in many parts of the country the local middle school has more technology, and is putting it to better use, than the local teacher education institution. In an era when harsh criticism of education, especially teacher education, is fashionable, some critics would be quick to conclude that the reason for the lag is a mediocre teacher education professoriate that is not up to the task of preparing the next generation of teachers. The one hundred plus papers in this book, and the expertise they represent, are a forceful argument against that hypothesis. The reports describe outstanding examples of successful technology integration in teacher education. The applications are extremely diverse. There are examples of CAI, hypermedia, interactive videodisks, simulations, telecommunications, and much more.

The applications also represent the range of instructional and learning theories. There are applications based on behavioral learning models, applications that express Piagetian developmental learning theory, computer applications based on learning styles research, and applications that articulate a cognitive science perspective.

The articles in this volume also represent several levels of thought. There are many "how to" articles that provide detailed information on a variety of ways to use technology. They are very helpful to those of us who want to use the techniques ourselves. These "how to" articles are supported by a number of articles we would describe as "context" papers, issue papers, and theory papers. Context papers address "big picture" questions such as the roles of technology in undergraduate education and the importance of general teaching strategies such as analogies. Issue papers ask critical questions, and propose some answers. Papers in this volume deal with issues such as gender equity and the role of technology in maintaining the educational status quo. Theory papers in this volume relate established and emerging general theories such as Constructivist, Structuralist, and Cognitive learning theories to the way technology is used.

Collectively the papers tell us that teacher education, as a technology-using field, is thriving. There are validated models, methods, and instructional packages for everything from a classroom management simulation to a state-wide telecommunications system that links K-12 educators and student teachers to university faculty. The "lag" in the uptake of technology in teacher education is not due to the lack of successful models. This book chronicles the pioneering efforts of several hundred technology leaders in teacher education. As a *new user* of technology, teacher education must compete with established computer-using disciplines such as physics, chemistry, and math for equipment dollars and support positions. It must compete at a time when higher education in many states is financially strapped. To some extent the future of technology in teacher education depends on the ability of teacher education faculty and administrators to convince granting agencies and university administrators that this is a field deserves support. Many of the projects described in this volume could not have been accomplished without grant support from corporations such as IBM and support from the project's university. As you read the papers, we think you will agree with us that the results to date more than justify the investments made thus far by corporations, foundations, and universities. With continued, and expanded, support, technology's contribution to teacher education in the nineties will be substantial

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Conference

Keynote Address

Information Technology in UK Initial Teacher Training (1981-1991)

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I am delighted to be able to share with colleagues in the United States the struggle we are going through in the U'. to improve the use of new technology in initial teacher training. This paper describes the educational scene in the UK and the development of computing in education. The routes to qualify as a teacher in the UK are described briefly before considering the development of Information Technology (IT). I describe some examples of what we consider to be good practice before discussing the issues which are causing difficulty in realizing this practice throughout the UK.

IT has much to offer education. Those without skills in the use of new technology already find themselves at a disadvantage when it comes to sifting through the deluge of information being published today. This applies to both the academic and commercial worlds. IT is also used to process and communicate new information with such tools as desktop publishing (DTP) and computer mediated communication. The spread of the ability to publish from a few specialists with a printing press to everyone with DTP software parallels the spread of writing by a few scribes two centuries ago to the present situation where almost everyone can read and write with the corresponding growth in education for all. The next wave of literacy may well be linked to the recent development of multi-media systems which incorporate images and sound along with text. This should encourage educationalists to expand *literacy* horizons again. Traditional pedagogy may be challenged, but extensive research and development are required. Meanwhile, the increased access to information in all its forms continues to challenge tutors [faculty] in teacher education, that is, when they can get hold of the new equipment required! *[Editors' note: British academic and teacher education terminology differs considerably from North American terminology. Much of the original British terminology has been retained in this paper, but a similar North American equivalent has sometimes been inserted in brackets after a term that is difficult to interpret from the context of the sentence.]*

Setting the Scene

Several factors set the scene for the use of IT in initial teacher training. TheY include the information technology itself, the structure of education in the UK, government initiatives, and the IT curriculum in UK schools.

Information Technology

The term *Information Technology* (IT) has been used in the UK since about 1987 as a general term covering all computer related activities in schools. The terms *technology, educational technology*, or *instructional technology* are used in much the same way in North America but I will use Information Technology in this paper because "technology" has another meaning in the UK relating to design and craft work.

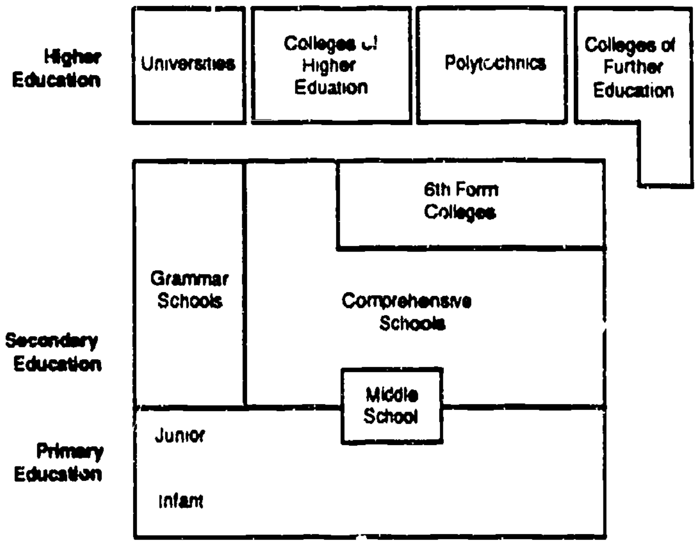

Figure 1: The Structure of Education in the UK

The following brief summary of new technology in education in the UK is given to set the context for IT in initial teacher training. Figure 1 shows the main elements of the system of maintained schools and higher education. There is compulsory schooling between the ages of 5 and 16. Teachers in government funded schools are required to be qualified [certified], which means they must have completed a course which is accredited by the Council for the Accreditation of Teacher Education (CATE). There are approximately 120 institutions which offer these courses in the UK. They currently train about 15,000 students each year. An alternative route has recently been opened for training "on the job" for students who already have an appropriate background, such as a relevant degree plus work experience. Lecturers in further and higher education do not require a qualification, except in Northern Ireland. The main routes to qualified teacher status are shown in Figure 2.

Government Initiatives and IT

During the past decade government funded programmes have had an important effect on IT in schools and had until recently kept the UK ahead of other countries. There has been a centrally funded service to develop IT in education since 1981. It started as the Microelectronics Programme and developed through The Microelectronics Support Unit into the National Council for Educational Technology. Scotland has a separate department of education with a similar support centre. This central organization works mainly through Local Education Authorities, which until recently were responsible for all grant maintained [public] schools within their regions. Information was disseminated, curriculum materials and software developed and in-service training provided. However, relatively little effort was directed at initial teacher training until recently because it was felt that in-service training would have "the fastest impact on

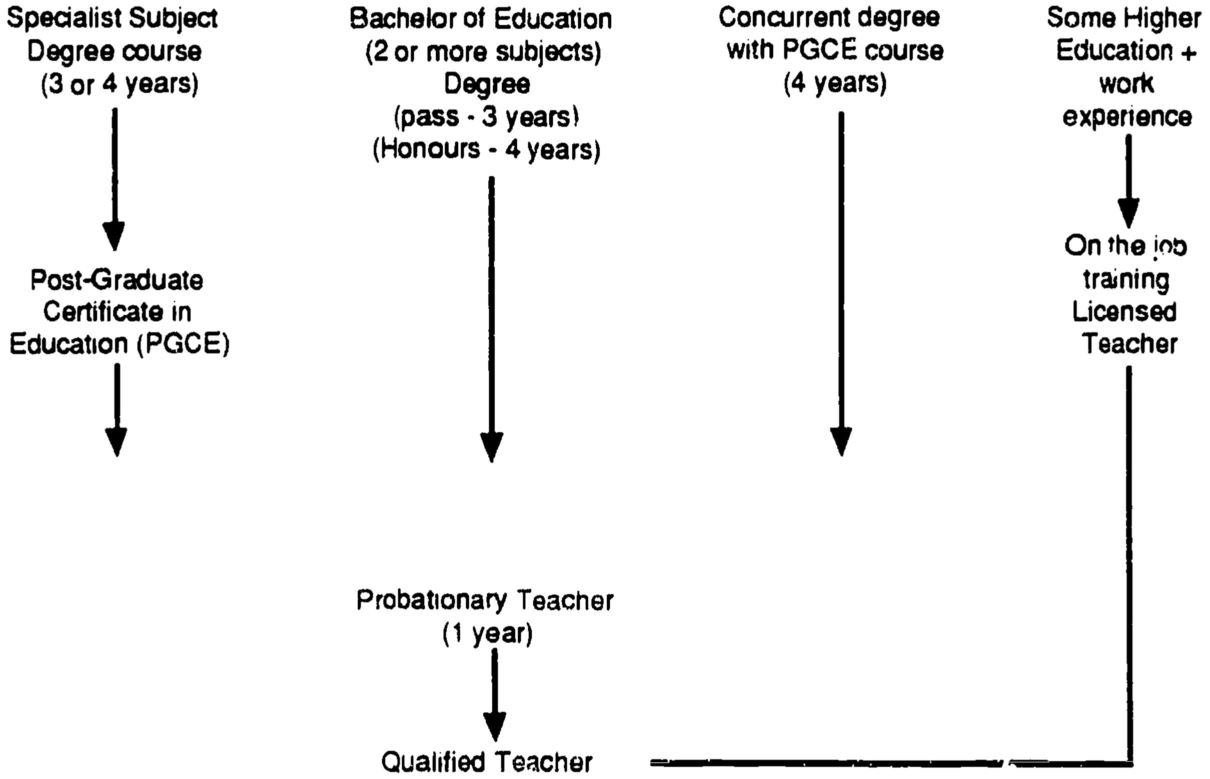

Figure 2

the contemporary classroom" (Fothergill, 1984).

Government funding has helped to provide hardware and software for schools in a number of schemes. The first was half the cost of one microcomputer for all primary and secondary schools, to be completed by the end of 1984. These were cassette tape systems, often without a printer, manufactured in the UK. Other schemes followed, approximately annually, with little time for planning. Most required partial funding from other sources. Teacher training institutions were rarely included. Training for practicing teachers was recognized as important from the start, but mainly for short courses. Advisory teachers and regional support centres have received national funding as well (for more detail see POST, 1991). These developments have resulted in an uneven distribution of equipment and a lack of trained teachers.

The IT Curriculum in Schools

In 1984 secondary school computing courses focussed on programming, hardware, information processing and commercial case studies. With time these examination courses changed to the study and development of applications rather than the study of hardware and programming. In the 1980s it became common to find an IT literacy examination taken by many less academic pupils in contrast to a few able students studying computing as one of the General Certificates of Secondary Education taken at 16 plus years of age. However, only in the last year or so has IT moved into subject studies [content areas]. Possible exceptions are mathematics and 'craft, design and technology' where IT has been applied in some schools for a number of years.

Primary school use of IT has developed very imaginatively since 1984. Like secondary education, primary schools use a variety of IT applications, such as word processing, DTP, adventures, databases, LOGO, art and music composition. These are usually integrated within a thematic context which many educationalists hope will spread to secondary schools. For a description of Inspectorate's [Her Majesty's Inspectorate of schools, no North American equivalent] view of good IT practice in UK schools see HMI (1989a). Straker (1989) described a range of classroom work. However, a national survey of primary teachers in 1989 showed that only about 14% felt competent to use a range of IT applications without assistance (Davis, 1990), which indicates this good IT practice is only experienced by a small percentage of primary children. The research base on the application of IT to teaching and learning is far from complete (see for example, Davis, in press).

In 1988 the Education Reform Act brought a National Curriculum to the UK for the first time. It is similar in England, Wales and Northern Ireland but does not apply to Scotland. The Secretary of State directed subject-specific working parties to incorporate IT into the curriculum where relevant. An assessment point dedicated to IT has been included within the foundation subject of Technology. The National Curriculum's staged implementation means that IT's assessment and cross curricular interpretation remain unclear. New applications of technology continue to be written into Parliamentary orders. For example, the use of satellite imagery is covered in geography.

The IT Curriculum in Preservice Courses

In 1984 the computing courses were optional and designed to equip secondary teachers to teach the subject of computer science. These courses have evolved with the change of computing in schools described above. A number of colleges offer main subject computing or IT as an optional subsidiary course. Computing is also a strong element of many courses for teachers of design and technology.

Since 1984 some colleges have encouraged other students, including students who will teach in the primary grades, to examine and discuss the role of computers in the teaching and learning of their main subject. However, inspectors have recently stated that "attempts at permeation were premature" as they rarely resulted in students becoming confident enough to handle the technology themselves. In 1988 Her Majesty's Inspectors published a report (DES, 1988) based on visits to institutions in 1986.

HMI found much good work in these areas; but concluded that overall the quality of provision was patchy, and that even where it was good it was not necessarily available to, or taken up by, all initial teacher training students. In particular, they expressed concern about the adequacy of organizational and management structures within institutions, and about the emphasis within courses on the technical details of the new technology at the expense of consideration of its curricular implications and potential in the classroom (DES, 1989b, p. 1).

As a result an expert working group was set up to identify the best current practice in the preparation of trainee teachers for use of IT in all areas of the curriculum and to make recommendations to ensure that all trainee teachers became competent in IT, within the time and resources available. The Trotter report, named after the chairwoman, (DES, 1989b) made nine recommendations. The most effective has been the adoption of an IT capability for students within the criteria for teacher accreditation shown in Figure 3. However, educational institutions, particularly universities, prefer to set their own standards rather than have them imposed by law. Thus it will take some time to ensure IT competence for all students. The final part of this paper considers some of the issues that are emerging.

The CATE Criteria

"(A) make *confident personal use* of a range of software packages and IT devices appropriate to their subject specialism and age range;

(B) *review critically the relevance* of software packages and IT devices to their subject specialism and age range and *judge the potential value of these in classroom use;*

(C) make constructive use of IT in their teaching and in particular to *prepare and put into effect schemes* of work incorporating uses of it; and

(D) *evaluate the ways in which the use of IT changes the nature of teaching and learning.*"

Figure 3. The CATE Criteria for Information Technology

Current Moves to Improve IT in Initial Teacher Training

Recent evidence suggests that short in-service courses can do little to develop the use of IT in schools (see for example Rhodes and Cox, 1990), yet that has been the normal practice. Had initial training been supported from the start, rather than concentrating on in-service courses, then it is possible that the UK could have a better trained workforce today. In July 1986 the Association of Information Technology in Teacher Education (ITTE) was formed to represent the collaborative views of all faculty in initial teacher education with a responsibility for IT. The report produced by the founding conference (ITTE, 1987) describes practice in 1986 and makes a number of recommendations. Most of the report remains applicable today. The report's authors clearly recognized the need for a pressure group and surveyed institutions to assess the extent of under resourcing, under staffing and under planning of IT (ITTE, 1988). ITTE runs a newsletter, an annual conference and provides courses for its members. However, probably its most important role is that of a pressure group to highlight the difficulties that institutions have in providing courses which prepare student teachers to use IT with confidence in the classroom to enhance teaching and learning. Following the Trotter report the National Council of Educational Technology has provided colleges with increased support in the form of courses and resources. There is also a collaborative project, Project Intent, across five institutions to develop their use of IT, funded by NCET and the institutions. I am a member of the Project Intent team and so have been able to develop and evaluate our IT work in Exeter University School of Education. Time and space do not permit me to tell you of our preliminary findings, but we do intend to disseminate them widely. Our first team paper was presented at the CAL91 conference in England (Project Intent Team, in press).

Secondary Courses for Students With a First Degree

Many courses that prepare students to become teachers incorporate IT using resources such as desktop publishing and videodisk technologies to support subject studies and provide students with opportunities to develop practical skills and a critical view of the place of IT in education. It is interesting to note that tutorial software is rarely used. It is not the UK style.

This year NCET has published an occasional paper called *IT's Geography: The Role of IT in PGCE Geography Courses* (NCET, 1991). It contains a very realistic description of the way IT is incorporated into teacher education at several institutions across the UK. It also provides a detailed description of the IT skills and knowledge geography majors brought to and took away from courses in 1989/1990. In the University of Southampton the IT elements are structured into four stages: introduction, preparation to use IT on teaching practice; using IT on teaching practice; and expanding the IT horizon. The publication also describes sessions with PGCE students which were tailored to the students' level and to the limitations of time. For example, one half-day session in the University of Sheffield used an interactive videodisk, *Volcanoes*, and a simple desktop publishing program to cover a number of objectives. The session developed ideas on using video without commentary introduced in the previous session, it modelled collaborative small group work, it raised some questions about marking, especially in relation to group writing, and it provided an IT experience. The task was to write newspaper reports about a volcanic eruption. The interactive videodisk provided both a lively stimulus and a detailed source of information in video, commentary and text. The evaluation of the session was very positive in several ways: the students appreciated the rich form of information provided on the videodisk; they were totally involved in the task of publishing a newspaper report; a lively debate on the issues of marking work developed; and they used ideas on teaching practice from the session in schools. Geography tutors have been greatly assisted by the provision of a large packet of materials from NCET (1988) which directly relate IT to geography with software, associated teaching materials, classroom reports and background reading.

First Degree Courses in Exeter for Primary Students

In Exeter we are aspiring towards good practice within the redesign of our undergraduate degree to accommodate several new criteria necessary for accreditation of the course. This year we are testing the main aspects which affect all students. A year 1 introductory course aims to give all students confidence to use a limited range of hardware and software within classroom practice they will see locally. It integrates with their concurrent weekly visit to a primary classroom. Primary tutors are able to build upon this basic competence when they use IT to enhance their degree level subject work and curriculum applications. For example, LOGO, introduced using a robot and a simple exploratory style during the introduction course, is developed by the mathematics tutor to teach programming for degree level work and shape in curriculum work. Although the introduction to IT is a separate course we aim to involve some primary tutors in its delivery which should carry over into their subject teaching. We also plan to team teach some advanced subject sessions which use IT. An integrated course in year 2 examines teaching and learning in some depth with the help of a primary school class who attend one day of the week at the Primary Base on the university campus. Students are required to use IT on at least one occasion with their small group of children over the two-term course.

IT may become a compulsory element of the teaching practice in the future. At present it is optional due to a number of practical constraints on resources and expertise. In the future there will be several optional IT extensions for students. Students may choose IT for their cross curricular assignment in Year 3. This takes the form of a study and essay for assessment towards the degree. There will be a subsidiary subject of IT which will aim to prepare students to become IT coordinators for their school. This is important because many past students have become IT coordinators, even before they complete their probationary period. IT will also form a significant part of some other subsidiaries, for example *design and technology.*

Issues in Providing IT For All Students

Five issues are involved in the provision of IT for all students preparing to become teachers: the structure of courses, access to IT resources, delivery of IT within subject specialisms [content areas], staff development, and host schools for student teachers.

The Structure of Courses

Each student will have a number of tutors, say 10 to 30. The size of teaching groups will vary from 1 to the whole year group, which may be over 100 in large institutions. There is normally a tutor responsible for IT and a few institutions have a team. A few institutions use IT services from other departments. Therefore in all but the smallest institutions the logistics of providing a course where IT is an integral part of the work is impossible unless all tutors become IT tutors in their subject specialism. This is far from the case. Figure 4 shows the use of IT across curriculum areas in 1988 (ITTE, 1988, p. 15). ITTE is currently resurveying all UK institutions.

Subject Area	Amount of Use				
	1 (none)	2	3	4	5 (all)
Professional Classroom Studies	11	22	5	8	0
Education Theory/Issues	27	16	2	3	1
Mathematics	0	1	3	15	30
English/Modern Languages	7	17	9	2	11
Art/Music	8	20	3	2	5
History/ Geography/Social St.	4	12	12	11	8
Science	0	9	5	15	20
Commerce/Business Studies	1	0	3	1	4
Physical Education/Dance	18	7	3	2	3
Religious Education	19	10	0	2	2

Figure 4. The Use of IT By Subject Matter

The Range of Student IT Experience

Students entering teacher education courses could be expected to have some experience with IT. However, surveys we have carried out continue to show that only about 30% of students have previous IT experience (for more detail see Davis, 1990b; Summers, 1990). Some students are very anxious about the use of equipment, especially computers, and for these students a slow, friendly introduction is important. At the other end of the range, students who have used sophisticated computer systems in commerce need to be shown how these relate to classroom practice. One student recently commented after a 10-hour introductory course for postgraduate primary students, "I learned more in this course than during my degree computing course."

Access to IT Resources

The aim is to support students so that they all become confident user of IT in the classroom. Necessary resources include many items, all of which need continual updating: hardware, software, books, accommodation, technician and tutor expertise. It is difficult to persuade those in charge of budgets that computers over 5 years old are unsuitable for teacher education and should not be counted towards the Trotter report's recommendation of 1 microcomputer per 5 students (DES, 1989b). Tutors are constantly engaged in gathering material such as curriculum materials and require support to catalogue it and make it available to students. Libraries need new skills to handle and use these media.

Delivery of IT Within Subject Specialisms

Extensive curriculum development is required to enhance subject work within curriculum courses and at degree level. School applications of IT need to be condensed to fit in the time available and to suit the students' abilities. They also need to emphasize the effect that IT has on teaching and learning. IT can enhance degree level work too but is rarely seen in this context. Some assistance is provided in the UK through the University Computer Board's recent *Computers in Teaching Initiative* (CTISS, 1990). Subject tutors [content area faculty] seem to go through several stages of professional development with IT. Classroom and commercial applications of IT may be simply demonstrated at first. After the tutor has had time to reflect then he or she can refine this IT experience to emphasize the salient points for students. One of my colleagues recently described her "pilgrim's progress" through this process (Horton, 1991). I have observed this process in a number of colleagues, and it would appear that tutors in initial teacher training require an additional stage of professional development in IT to become practicing teachers in the classroom. In addition, experienced tutors require access to leading edge IT applications with time to experiment in an educational context. Unfortunately all these aspects of curriculum development happen rarely within present funding restrictions.

Staff Development

Staff development for tutors is an enormous task. One approach is to identify an IT application which should appeal to particular tutors for their teaching or other work, preferably the former. This frequently involves team teaching. Courses for software or curriculum areas catch other tutors. Recently the senior management, and HMI, highlighted the need for all tutors to be able to support and evaluate the use of IT by students in schools they supervise. One of Her Majesty's Inspectorate recently suggested that tutors supervising student teachers in schools should look critically to assess whether the use of IT is appropriate to the subject being taught. This is particularly difficult for tutors who supervise the teaching of a subject which is not their specialism and includes the majority of primary supervision.

Host Schools for Student Teachers

IT can only be one of the many factors considered when choosing schools where student teachers will observe and practice teaching. The school and its staff will frequently need the support of the initial teacher training institution to develop good IT practice and resourcing. The schools need an IT policy which recognizes the particular constraints facing student teachers and the students need to recognize the constraints which affect the school.

Conclusion

The enormous potential of IT to change the focus of education from teaching to learning can be contrasted with the spread of literacy which resulted from the printing press. For this and other reasons skills and competence with IT are now a requirement for all UK student teachers. It is therefore important that most tutors in initial teacher education learn to make appropriate use of IT in their teaching and that they assist students to evaluate the effect of IT on teaching and learning. Much curriculum development remains to be done to realize this, but an exciting range can be seen in the UK today. Many issues arise when delivering IT to students in training: structure of IT experiences within courses; the range of students' IT expertise; access to IT resources, the delivery of IT with subject studies; staff development; and relationships with schools which host the student teachers. It will therefore continue to be important for us to fight for support for the continued development of IT in initial teacher training and I am delighted to be able to share a UK perspective with researchers and practitioners in

North America. I feel sure we can collaborate to our mutual benefit.

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PRESERVICE TEACHER EDUCATION

Introduction

The history of instructional computing is a short one, but, in this short period, dramatic advances in technology have developed and instructional directions have emerged. The first generation of instructional computing was typified by large mainframes delivering tutorials—mostly drill and practice sessions—to small, select populations. These efforts were expensive and limited to minute instructional goals.

The second generation showcased microcomputers with very little primary memory and inefficient devices for external storage. The emphasis during this period centered around programming, historical topics, and microcomputer architecture. Again, only small, select groups of students were exposed to the technology.

It wasn't until the development of low-cost microcomputers having 48KB or more of internal memory and disk drive systems that the instructional computing movement began in earnest. During this third generation, the emphasis extended beyond programming, computer history, and architecture to Logo and the use of small programs to deliver instruction. Talk was generated about the marvel of computer assisted instruction and the cognitive rewards of using Logo, yet the promise of this dialogue was never realized. Even so, it was clear that computers were going to have a permanent impact on society and education.

As inexpensive generic programs, such as word processors and data-base managers, and as a variety of computer peripherals became common in the marketplace, schools scrambled to define the objectives of a new computer literacy that was going to be required of all individuals. Thus, a fourth generation was underway and the focus once again was teaching about computers, computer peripherals, and software tools. In the process, the fact was obscured that computers, despite their power, are no more than tools for human achievement, just as hammers, saws, and brushes are. More than being objects for instruction, they should be vehicles for teaching and learning, whatever the subject area.

Many educators, not satisfied with the first four generations, called for a fifth generation wherein educators focus on using technology to invent new instructional systems, new roles for teachers, and new expectations for students (Troutman & White, 1988). From a consideration of educational programs at all levels all across the nation, it is obvious that in 1991, this fifth generation is underway. The articles included in this section make it abundantly clear that educators concerned with preservice teacher education are initiating changes and grappling with related issues. As in the early stages of any transition, the development is taking place on a broken front, so it is not surprising that the articles here range broadly in their themes.

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The Big Picture

Some of these writers are concerned with the big picture. Niess concerns herself with redefining exit goals related to technology for teachers—what all preservice teachers should know. Digranes & Digranes answer the question "How and when do I as a teacher integrate the computer into my classroom activities?" by using technological strategies to interpret Hunter's mastery teaching model: the Lesson Line. White identifies and addresses a major issue: how do we conceptualize and make explicit to preservice teachers a model for understanding the process of using computing as an enabling technology.

Preservice Training Models

Other writers have shared with us the valuable outcomes of their experiences implementing preservice teacher education in technology. Dershimer & Dershimer relate the process of developing an integrative model in a small, liberal arts program. Cathy Gunn describes the travails of a similar effort at a larger institution. Vitale and Romance use videodisk technology within the content of a science course for elementary preservice teachers. These programs seek to develop competencies by integrating the use of technology into many different courses taught by many different faculty in many different subject areas. Bauer & Grzenda and Blackwell get at the matter from another end of the spectrum. Each redefines the implementation of comprehensive technology courses that are generic in nature and that have broad appeal.

Content Area Integration

Roos, Taylor & Kemp, Wheatley, and Tronie Gunn describe their pioneering and research efforts in their areas of specialization. These authors cover the integration of technological efforts into K-8 language arts, research on anxiety reduction in standardized test preparation, computer use in a college-level developmental reading program, and the use of technology to teach about the area of computer studies itself.

Yes, Virginia, There Are Other Forms of Instructional Technology

Finally, Pantelidis keeps the titles of this conference and publication honest by addressing a form of technology other than computers: robotics. She outlines robotics as a content area and describes its use as a teaching methodology.

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Preparing Teachers for the 1990s

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According to the 1988 National Assessment of Education Progress project titled "Computer Competence: The First National Assessment" (cited in "That Does Not Compute," 1988), schools have only dented the ignorance most students and teachers have about computers. The study found that "schools have failed to use computers effectively and teachers are trained inadequately." A 1989 poll, "The Computer Report Card: How Teachers Grade Computers in the Classroom", found that two-thirds of the U. S. teachers now use classroom computers; however, 59% of the teachers responded that most teachers are inadequately trained in computer use while 52% of the teachers consider themselves less computer literate than their students (cited in "Most Teachers," 1989).

What changes, if any, should be made in the preservice and inservice computer education courses in order to adequately prepare teachers for the 90s? In 1983 the Northwest Council for Computer Education (NCCE) funded a project to develop a set of guideline competencies for teacher preparation programs. (Moore, 1984) Are these competencies adequate for the 90s? Or, has the impact of computers in education altered the education teachers need in order to be computer-using educators?

NCCE and Oregon State University funded a follow-up project to investigate this question and to provide information for reevaluation of teacher education programs. This paper presents the guideline competencies for all teachers at the elementary, middle school and high school levels. A comparison of these competencies with the competencies developed in 1983 provides a foundation for recommendations for changes in preservice and inservice teacher education programs as well as for changes in the curriculum.

The Competencies

A modified Delphi design utilized current computer-using educators in elementary, middle and high schools. Approximately 20 classroom teachers with a variety of teaching assignments were identified at each level; size of school, geographical region and type (district versus school) of institutions were also considered in the selection of the specialists. Specialists identified, refined, and ordered the following sets of competencies.

Category 1. Every elementary school teacher should:

- fit the computer to the curriculum, rather than the curriculum to the computer;
- obey copyright laws and discuss ethical issues of computer use;
- use the computer as a personal and professional tool;
- integrate, where appropriate, applications of the computer (computer assisted instructional software, word processing written compositions) in a variety of

subject/content areas, in a variety of teaching/learning strategies (cooperative learning, individual learning, problem solving);
- use basic computer terminology;
- demonstrate familiarity with the everyday operation of computer hardware and software in order to "trouble-shoot" minor problems and with various computer lab structures and their management;
- use computers in his/her own learning of subject matter;
- demonstrate familiarity with computing topics and educational materials available for elementary level;
- use a variety of sources for information on computers in education;
- demonstrate knowledge of the impact of computer-based technology on our society, including present and future uses of computing technology in home, school and work;
- instruct students in keyboarding, using appropriate media, and software resources.

Category 2. Every middle school teacher should:
- fit the computer to the curriculum, rather than the curriculum to the computer;
- obey copyright laws and discuss ethical/social issues that result from increasing presence of computers in our society;
- integrate, where appropriate, computer uses, applications and topics (including computer-as-a-tool applications, vocational opportunities, multi-media techniques) in a variety of teaching/learning situations in a specialization area;
- use the computer as a personal and professional tool;
- demonstrate and teach familiarity with computer hardware, including everyday operation of a variety of machines, everyday operation and use of custom features of classroom machines, and minor "trouble-shooting" of basic equipment problems;
- use basic computer terminology;
- use computers in his/her own learning of subject matter;
- use a variety of sources for information on computers in education;
- identify, use, teach, and correct keyboarding skills of students.

Category 3. Every high school teacher should:
- fit the computer to the curriculum, rather than the curriculum to the computer;
- use the computer as a personal and professional tool;
- obey copyright laws and discuss ethical/social issues that result from increasing presence of computers in our society;
- demonstrate knowledge of the impact of computer-based technology on our society including present and future uses of computing technology in home, school and work;
- design and implement appropriate computer uses and applications (including multi-media technology, simulations, CD-ROM, databases, hypermedia, telecommunications) in a variety of teaching/learning situations in a specialization area;
- use basic computer terminology;
- use computers in his/her own learning of subject matter;
- demonstrate to students familiarity with computer hardware, including the everyday operation of a variety of machines, everyday operation and use of custom features of his/her classroom machines, and minor "troubleshooting" of basic equipment problems.

Comparison With 1983 Competencies

A comparison of these sets of competencies with a similar set developed in 1983 (Moore, 1984) assists in recognizing exactly what is being suggested. Two issues in the development of the 1983 competencies, keyboarding and programming, were dealt with quickly by the 1989 evaluators. Keyboarding should be taught, the "earlier the better," in "a lab situation." An artifact of the past, programming, was quickly removed from the list of possible competencies. In its place, the evaluators emphasized the use of software applications for teaching, learning, and classroom management.

Probably the most significant change in the competencies since the 1983 set, is a change in the verbs. In 1983 the verb phrases were more passive as well as less demanding. Verb phrases changed from "should have knowledge" (in 1983) to "should use" (in 1989). In 1983 teachers only needed to "have knowledge of computer vocabulary" (Moore, p. 50); however, at each level of the current guidelines, teachers must "use basic computer terminology." Also, the new sets clearly state that all teachers, regardless of level, need to "use computers as a personal and professional tool." The change in this statement from the 1983 guidelines is more subtle. In 1983, the teacher should "be able to use the computer as a tool" (Moore. p 50). Whereas in the past, the teachers needed only "to be able to use the computer as a tool", now, there is an expectation that the teacher, in fact, will use the computer as a personal and professional tool.

Meeting the Guideline Competencies

Can teachers meet these guideline competencies? What changes, if any, do these competencies suggest for teacher preparation for the 90s? What changes, if any, do these competencies suggest for the curriculum?

Preservice teachers must have a general education about computers early in their college preparation, not in the final year of the teacher preparation program. They must have instruction in general concepts about computers, computer terminology, impact of computers on and in society, and use of variety of hardware/software available to them in their college program. They must be able to use computers as learning tools throughout their college program.

Teachers of teachers must use computers as personal and professional tools if the preservice teachers are to use them as personal and professional tools. Colleges and universities must provide programs to assist the professors in learning to use computers as personal and professional tools and to assist them in redesigning their courses to integrate the capabilities of the computer.

Preservice teacher education programs must move away from the single course idea, the computers in education course. Preservice teachers must have an education that integrates teaching with computers and related technologies throughout the entire program. Methods courses must consider the development of lessons that integrate computing technology. Practice teaching situations must have computing technology available. Seminars must include discussions of issues and problems of integrating computing technology in teaching of specific subject matter. As long as computer technology is treated as an add-on to the teacher education program, it will continue to be an add-on in public education. In order for teachers to meet these guidelines they must have a continued involvement with and experience in using computers.

The dynamic nature of computing technology and its impact on education requires teachers to have a solid educational background about computers and about computer applications in education upon which inservice training must build. Teachers must continue to learn with the changes in the technology. Inservice education must focus on assisting teachers to identify new applications, to implement changes in the technology, to take advantage of changes in the technology. Teachers cannot be expected to do this part on their own.

Notice that the first competency in each set is that the teacher should "fit the computer to the curriculum, rather than the curriculum to the computer." The competency provides an interesting dilemma for teachers. The power of the technology is changing the way society operates. It is changing what is important to be able to do in society. Few people balance a checkbook without the use of a calculator. Databases are commonly used in identifying individuals who may be a bad credit risk. Tellers don't make change, computers do. Yet, today's curriculum leans on the needs of the past. If teachers are to fit the computer to the curriculum, rather than the curriculum to the computer, they will surely have to treat it as an add-on. Therefore, probably the most important recommendation emanating from these guideline competencies is that the curriculum must be reevaluated and revised. Changes in the curriculum must reflect the changes in the ways the society works. According to Friel (1990-91), " We do not need to make changes simply for the sake of using technology, but we do need to make changes in order to reflect changes in the ways we think about and work within disciplines as a result of the enhanced intellectual power provided through technology."

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Choosing The Appropriate Instructional Moment For Computer Integration Using Madeline Hunter's Lesson Line

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There is no question that computers, to be effective in instruction, have to be successfully integrated into the ongoing instructional activities within the school curriculum. The question that emerges is "How and when, do I as a teacher, integrate the computer into my classroom activities?" Gesert and Futrell (1990) described integrating the computer into the classroom as an activity consisting of three (3) components: (1) planning the physical environment, (2) planning for appropriate computer usage, and (3) planning for the computer to "take on designated curricular functions" (p. 164). This paper focuses upon the curricular component, reviewing current strategies and proposing a different approach based upon the structure of Madeline Hunter's Mastery Teaching model, the "Lesson Line" (Hunter, 1982).

Current Strategies

A variety of instructional strategies have been proposed in the literature. General principles for computer use have come from media selection principles, such as learner characteristics, task requirements, transmission mode, and material practicality (Briggs & Wager, 1981). Trollip and Alessi (1988) suggested that computers be used when it is difficult or costly to use other media, when the instruction is to be individualized, or when the computer/software may provide motivation to students.

Gesert and Futrell (1990) recommended analyzing the standard curriculum and the curriculum objectives to evaluate the feasibility of using a computer. "Some objectives may invite computer assistance; others lend themselves to it; many will not" (Gesert & Futrell, 1990, p. 177). The educator also must consider if software is available, even though use of a computer may be appropriate. Specific examples described by Gesert and Futrell (1990) include modeling and practice activities within a scientific skills lesson. The emphasis was upon matching the capabilities of the computer to the instruction.

Wedman (1986) stated that instructional software can be integrated into the curriculum to provide a lesson if the teacher (1) analyzes the program and identifies the instructional events (based upon the nine identified by Gagne) that are missing, and then (2) supplies those events which are missing. Many software programs are not stand-alone, so the teacher complements the software by providing the missing events. For example, if the software did not state the objectives (the second event of instruction), the teacher would inform the learners of the objectives to be accomplished. If the software did not provide sufficient assessment of performance (the eighth event of instruction), the teacher could prepare additional written tests for assessment.

Pogrow (1988) suggested that a variety of computer implementation strategies be developed. The strategies would be based upon the individual student and the educational objectives to be achieved. He stressed that an approach which treats everyone the same should perhaps be changed to another, more important goal " to improve everyone's thinking ability to the fullest extent possible" (p. 6). He stated that there are probably optimal grade levels, content areas, and student groups for computer use. For example, teachers he surveyed reported that fourth grade high-performing students and fifth grade underachieving students were at optimal grade levels for intensive word processing. These optimal points, in most areas, have not been determined.

Vocknell (1990) recommended that student use of computers be based upon instructional principles to successfully implement planned instructional strategies. Instructional principles included were in the areas of mastery learning, overlearning and automaticity, cooperative learning, monitoring student progress, immediate feedback, learning styles, and classroom management. One example included guidelines for using computers to promote overlearning:

1. Use computer programs to provide self-paced, individualized practice.
2. Use computer programs that provide gamelike practice for skills that require much repeated practice.
3. Use computer programs that provide varied approaches to practicing the same activity. (p. 13)

Vocknell stressed that the computer is most effective when it contributes to the implementation of specific instructional strategies.

Other approaches have emphasized instructional principles, in addition to curriculum design. System-wide curriculum planning must consider cooperation, continuity, comprehensiveness, and coordination (Stewart, 1989-90). These terms were defined as:

1. Cooperation—The system is dependent upon the collaborative efforts and input of teachers and curriculum/supervisory personnel.
2. Continuity—The system ensures the articulation of the various subject areas' teaching-learning components, both within and between grade levels.
3. Comprehensiveness—The system is characterized by each subject area's total spectrum of components being organized around the subject's full array of study topics.
4. Coordination—The learning objectives, for all subject areas, are integrated with their related content items, activities, materials, and evaluation devices (p. 106).

Stewart emphasized that the design of both individual computer software packages and total instructional packages be based upon system-wide curriculum planning.

Three stages of software integration into the curriculum and classroom were described by Troutner (1986). The first stage was a media substitution stage; the computer software was substituted for another form of media in the classroom. She recommended drill and practice, tutorial, and teacher utility programs for the first stage. In the second stage, computer courseware was integrated into the curriculum, accompanied by a change in the teacher's methodology. Problem solving programs, authoring languages, and programs which can be modified by teachers were examples presented as appropriate for the second stage. The third stage incorporated computer courseware "which requires a change in the organization of the school, training of teachers, and the objectives and methodology used in the classroom" (p.87). Programs for this stage included simulations, interactive video, data bases, and other application programs. She also emphasized that the computer courseware must enhance the curriculum; choosing courseware should be based upon its fit with the curriculum, not just on personal likes and dislikes.

A Strategy Based Upon Hunter's Model

We propose linking computer integration to a direct instructional method, which is widely used in teacher education programs, as well as in elementary and secondary schools across the United States. We recommend training preservice and inservice teachers to choose the "how" and "when" by integrating computer use into Madeline Hunter's Mastery Teaching model, the "Lesson Line" (Hunter, 1982). The Lesson Line provides a model that describes what effective teachers do when they teach a lesson. A teacher can develop a plan for integrating the computer into the curriculum by matching computer/software capabilities to the Lesson Line components. The three major components are: (1) Anticipatory Set, (2) Teaching to the Objective, and (3) Closure.

Anticipatory Set, which leads the learner to anticipate the lesson, includes (a) involvement of the learner; (b) relate to past, present, and/or future; and (c) statement of the objective. When the learner is involved, the learner is interested in and is participating in the learning. Learning can be related to students' experience, either what has occurred in the past or what is in the present or future. Statement of the objective involves the learner by telling the learner what is to be learned.

Teaching to the Objective involves generating in the learner overt behavior that is relevant to the learning. Included are: (a) explanation, (b) questioning, (c) responding to the learner in terms of the learning, (d) direction giving, and (e) activities, both guided and independent. Explanation refers to the method in which the instruction is presented. There are six (6) recommended methods: (1) definition, (2) content, (3) process, (4) model, (5) example, and (6) modeling. Questioning is used by the teacher to check for understanding or to keep students involved; questions may be directed to individuals or groups. Responding includes (1) saying the student's name, (2) clearly accepting or rejecting the student's response, and (3) repeating the learning. Direction giving engages the students in interactions with the explanations and the activities. Activities are either guided, closely monitored by the teacher, or independent, which can be done without the assistance of the teacher.

Closure is the pulling together of what was learned in the lesson through (a) involvement of the learner and (b) summary. The teacher involves the learner by questioning or directing the student to summarize the lesson. Summary includes recalling the main points, concepts, and/or purpose of the lesson. The teacher maintains the focus of the learner through the closure activities.

By analyzing these Lesson Line components and the attributes of the computer/software, it is possible to choose the appropriate instructional moment for computer use in the curriculum. In a social studies class where students are debating current political issues, an activity could be designed involving a computer-driven survey. This survey could query students on their opinions. This activity meets the criteria for Hunter's design element: Teaching to the Objective. Closure would be provided when survey results were computer tabulated, summarized, and compared to the content studied. The following examples are possible applications within the Lesson Line structure.

Anticipatory Set

1. Involvement of the learner: The computer is excellent for involving the learner. A simulation could "hook" the student prior to the lesson. A geography simulation or game would provide a good introduction to a study of world geography.
2. Relate to past, present, and/or future: In a science class beginning a unit on earth science, a software simulation on the history of volcanoes or earthquakes could both involve the learner and relate to the past.
3. Statement of the objective: Many software packages inform the learner of what is to be learned during the lesson. If the software package is only part of the lesson, the teacher will state the objective; but the teacher can use software presentation tool to present the objective visually to the students.

Teaching to the Objective

1. Explanation: A tutorial could provide the information to the students. The tutorial may include definition, content, process, a model, examples, or modeling of what is to be learned. For example, a tutorial on fractions explains the processes for computing fractions, as well as presenting examples of problems. Graphics software provides opportunities to present realistic models of anything ranging from car engines to the human body.
2. Questioning: Questioning may be best performed by the teacher, but newer and more sophisticated software packages include opportunities for learners to review information if the learner does not understand the concepts. The software prompts the learner to indicate if review is needed. The learner could also be in the questioning role. New storybook programs allow the learner to "question" a word or a picture by clicking on the word or picture; the definition of the word or the name of the picture is then presented.
3. Responding to the learner in terms of learning: Computer software can respond to a learner by name, can clearly accept or reject the learner's response (very quickly, also), and can repeat the learning. The reporting features of software can assist the teacher in responding to the learner by providing the learner's performance data to the teacher in a report format, either on screen or in a printout.
4. Direction giving: The computer can be very good at providing directions. Prompts and help screens are common features in software. Much software is user-friendly, thus minimizing the need for directions. The teacher may have to provide general directions for the lesson, but the software itself will provide its own specific directions. An exception may be application software, which requires previous training and directions for optimal use. But manuals and computer tutorials are available to assist in providing directions to learners.
5. Activity: The computer can assist the teacher in providing guided activities, keeping track of students' progress and branching based upon the students' performance. In many software systems, the modules can be developed based upon a linear or random access mode. If the linear mode is selected, a student could not move to the next learning activity until the prior activity was completed successfully, thus providing feedback for the student. The teacher still has to provide specific information regarding student performance. The random access model can provide independent activities for the student. The student would be free to choose the activities in any preferred order, thus providing independent practice.

Closure

1. Involvement of the learner:
2. Summary: The students could word process a summary of the lesson. The summary would include the main points or concepts of the lesson, thus providing a summary of the lesson, as well as the involvement of the learner. A storybook program

could also provide involvement for the learner in summarizing the lesson; a student could create a story about a particular character or era in history.

(Additional examples of lesson plans using this approach are included in "Teaching Teachers About Technology" (Wiburg, 1990).)

The focus upon teacher training in computer education (Bruder, 1989; Hannafin, Dalton, & Hooper, 1987; Jacoby, 1985: Moore, 1984) is an integral aspect of integrating computers into the schools. It is the role of the teacher educator to assist preservice and inservice teachers in answering the "how" and "when." Utilizing instructional models, such as Madeline Hunter's model, and adapting computer use to these models can provide pragmatic strategies for teacher educators and for teachers.

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Conceptualizing Computer-Based Teaching

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The central thesis for this paper, I have discovered, can be described very well with a few well-chosen citations from the sources that I consulted in the process of writing it.

> "Teachers are unsure how computer activities fit in." (Roblyer, 1989). "Central to its (the computer's) use is how educators conceptualize the computer using process. In the final analysis, it is the teacher who must decide if, when, and how computers will be part of the educational enterprise." (Adams & Fuchs, 1986). "A vital ingredient to successfully integrating computers into the classroom is the teacher's own frame of reference." (Adams & Fuchs, 1986). "The many seemingly unrelated applications make more sense when they are considered within the context of some kind of classification scheme." (Bullough & Beatty, 1991). " ... (a) framework may be beneficial in understanding, at the outset, what may seem like a complex field." (Taylor, 1980). "There are still too few adequately conceptualized frameworks for computer applications to provide generic guiding principles or guidelines for educational computing." (Adams & Fuchs, 1986).

Because of the newness of the instructional computing field, I suppose, sets of terminology are only beginning to be standardized and conceptual frames of reference are only beginning to emerge. The novice is currently confronted with a bewildering array of acronyms and jargon that resist being organized into a cohesive whole. I did not always see this as an important problem—it seemed to me that the multitude of concepts to be learned and skills to be developed were much more important for teachers to address. This attitude may have been a result of teaching mostly graduate courses (as many instructional computing educators do), in which I tended to focus on some specific aspect of computing, and never teaching a course in which I sought to portray the field as a whole. But, after three years of teaching an undergraduate *Introduction to Computers in Education* course to 200-300 students per semester, in which I was obliged to address the broad scope of the subject, I find that Roblyer, Adams & Fuchs, Bullough & Beatty, Taylor, and I are in full agreement. After struggling with trying to assist students in seeing the "big picture" of instructional computing, I have become convinced that I must require them to be able to recognize, to understand, and to apply terminology related to the classification of characteristics, behaviors, and events related to the uses of computers for teaching and learning.

Having developed some ideas over the past few years about how to characterize instructional computing to novice teachers, the second step in my method was to review the thoughts of others on the subject. So I identified and acquired copies of approximately 30 recent (none published earlier than 1979) references on the subject of introducing teachers to technology, most of them textbooks, and reviewed them for their use of conceptual models and related terminology. If it is not already apparent to the reader, it is important to note at this point that the scope of this thesis deals exclusively with computers as an *enabling* technology—that is, how one uses computers to teach and learn about other subjects. It does not deal with computers as a curriculum—what is often called computer literacy, programming, and/or applications and considered to include such topics as teaching about how computers work, programming, and computers in society. It is also important to note that the ideas discussed in this paper deal only with actual, current uses of computers, not with proposals of ideal uses.

In my review of the 30-some texts, the dominant view that emerged was that teaching teachers about computers in education amounts to teaching them about courseware and its evaluation, high-level programming as a tool for developing logic and problem-solving skills, use of the computer as a tool for instructional management using specific (e.g. gradebook) or generic applications software (e.g. wordprocessors), and the extension of the use of applications software to the students, for their own productivity. If, based upon your experiences in teaching and research, you believe as I do, that a broader perspective is required, then I submit to you the following assertions.

Teachers must have an understanding of concepts related to three general areas:

- What computers can do,
- What learners can do with computers,
- What teachers can do with learners and computers.

Teachers must also be provided with terminology for discourse in these areas.

Computer Characteristics, OR Terminology Related to What Computers Can Do

Other than high level programming language terminology, the most widely accepted and employed language related to computers in education today relates to what I (and most of the authors cited here) refer to as the *Computer-Assisted Instruction (CAI)* terminology. This language springs from the earliest vision of computers in education: the computer-as-teacher. It is almost always subdivided into *tutorial*, *drill and practice*, *problem-solving* (although the computer usually *poses* the problems rather than solving them), and *simulation*. O'Shea & Self (1983) and Hentrel & Harper (1985) are examples of texts that rely primarily on the CAI language, but every text that I reviewed contains the CAI language or some variation on it. Among the more popular variations observed were: the substitution for CAI of such terms as Computer-Assisted Learning (CAL), Computer-Based Education (CBE), Computer-Managed Instruction (CMI), and Computer-Based Instruction (CBI); inclusion of the category *game* among the three basic sub-categories; and infusion of the entire genre with elements of artificial intelligence to create Intelligent Computer-Assisted Instruction (ICAI).

Other texts extend the concept of what computers can do with terminology describing software that was developed primarily for non-instructional purposes, but which we use extensively in education (Pantiel & Petersen, 1984; Alessi & Trollip, 1985; Coburn, Kelman, Roberts, Snyder, Watt, & Weiner, 1985; Adams & Fuchs, 1986; Bitter & Camuse, 1988; Roblyer, 1989; Flake, McClintock, & Turner, 1990). The most widely used categories are *wordprocessors*, *database managers*, and *electronic spreadsheets*. Those terms are often augmented with additional categories such as *graphics utilities*, *telecommunications*, *integrated software*, *desktop publishing*, and *numerical analysis*. Collectively, these terms comprise a set that I choose to refer to as *applications* terminology.

Given the intended audience for this paper and the relatively widespread use of the CAI and applications terminologies, I have not defined any of the terms here. The reader who requires assistance in this regard is advised to find a quiet spot in which to critically evaluate a few dozen typical educational programs and to consult some of the many works that I have cited here. (This is an opportune point at which to offer my apologies in advance to all authors whose intents differ from my interpretations of their respective works. I also caution the reader not to make inferences as to the overall quality of any of these texts based upon my very topic-specific consideration of them.)

I have so far referred to the CAI and applications terminologies as defining *categories* of software. That is what most of the texts do (to some degree the practice cannot be avoided); treating tutorial, drill & practice, word processor, and the like as mutually exclusive, rigid categories. But when was the last time that you used a good tutorial that did not also contain elements of drill? Aren't there problem-posing elements in many simulations? What good courseware doesn't contain elements of computer-managed instruction? Weren't the early integrated spreadsheets also databases and graphics packages? Do they belong in the same category as the second generation of integrated software? Some applications programs do not clearly belong to any major category. These are all objections that have been raised by my students. Especially from the perspective of a novice, software changes too rapidly to fit comfortably into discrete categories. A more insidious problem is that by referring to categories of software we imply, by association, that there are limits on how software can be employed for learning. Tutorials are for tutoring; so, are database managers only used for managing databases and electronic spreadsheets only used for financial modeling? If so, what a surprise that must be to the social studies and science teachers who use database managers and electronic spreadsheets for the conjecture and testing of hypotheses.

I contend that it is important to understand that none of the CAI and applications terminology should be viewed as identifying *categories* of software. I find it much more clear to consider them as defining software *characteristics*. It is not important for us to attempt to resolve all these terms into a "correct" and/or complete set. Certainly, distinctions exist among the many different acronyms and one can argue their relative merits. One might agree with Pantiel & Petersen (1984) that *game* is more a format than a category. One might also argue that, given the lack of progress in artificial intelligence, ICAI is a self-contradictory term. But, each of these arguments is confusing to the novice and none of them is as important as leading the novice to understand that all the terms describe the characteristics of *potentials* that exist in the computer for interacting with learners and teachers.

Learner/Computer Interactions, OR Terminology Related to What Learners Can Do With Computers

If, as I have suggested, one should not use the CAI and applications terminologies to characterize how computers and software can be used for learning, then how does one proceed? Many of the texts that I reviewed (Rushby, 1979; Taylor, 1980; Bork, 1985; Favaro, 1986; Kinzer, Sherwood, & Bransford, 1986; Merrill, Tolman, Christensen, Hammons, Vincent, & Reynolds, 1986; Siegel & Davis, 1986; Snyder & Palmer, 1986; Brownell, 1987; Maddux, 1988; Roberts, Carter, Friel, & Miller, 1988; Lockard, Abrams, & Many, 1990; Bullough & Beatty, 1991) provide part of the solution by addressing (not always explicitly) the concept of *mode* in which learners encounter computer use.

By far, the most widely accepted scheme for conceptualizing the modes in which learners use computers is the one offered by Taylor (1980). Taylor's *Tutor/Tutee/Tool* model offers an appealing way of looking at learner/computer encounters based on the locus of control during the learning experience, the degree to which the learner's intellect is actively or passively engaged, and the didactic or inductive nature of the learning experience that takes place. Indeed, it is this model that is propounded in one form or another by most of the other authors. I believe that all teachers and computing educators should be acquainted with Taylor's model. But, recognizing that it is not as widely endorsed as the CAI and applications terminologies, and having observed that it is misinterpreted by some educators to represent *categories of software*, I will summarize it here.

Learner as Learner/Computer as Tutor (Tutor)

In what Taylor calls the tutor mode, the computer delivers the lesson to the student. An example would be the use of software with tutorial and drill characteristics in which the computer is the locus of control during the instructional event. The learner most often plays a passive role and the instruction is didactic more often than not.

Learner as Tutor/Computer as Learner (Tutee)

In the tutee mode, the student programs, or "teaches", the computer to perform a task or to solve a problem. An example of software employed in tutee mode is the use of Papert's Logo (Papert, 1980) to provide the learner with a programming environment for "discovering" properties of mathematics and science by "teaching" the computer new procedures and rules. Depending upon the degree to which the learner's inductive processes are guided by the human teacher, the locus of control during the learning experience lies with the learner or the human teacher, and the degree to which the learner's intellect is actively engaged varies accordingly.

Learner as Tool-user/Computer as Tool (Tool)

In the tool mode, a computer and appropriate software are used by the learner to augment his or her intellectual abilities in much the same way a crowbar augments his or her mechanical abilities. Two examples of using the computer as a tool are writing with word processing software and creating art with graphics software. Again, locus-of-control depends upon the degree to which the learner is guided by the human teacher, as does the degree to which didactic or inductive strategies are employed.

Additional interesting perspectives on Taylor's modes are implied by Favaro (1986), who considers how modes of computer use reflect behavioral or cognitive approaches to the psychology of learning, and Siegel & Davis (1986), who consider computer learning modes in the context of process-oriented versus product-oriented approaches.

I have joined the many educators who have found Taylor's model to be of value to themselves and to their students. The reactions of my students have revealed two problems, however, in their abilities to readily grasp it. The first problem is that, although Taylor's model relates to how the learner encounters the computer, the names of the modes misleadingly describe the *computer's* role rather than the *learner's*. One solution is to rename the modes, but I consider the cure worse than the disease. The model is already too well-entrenched and I am also unwilling to risk losing the powerful alliteration.

The second problem is more fundamental. I have come to believe that the current range of software characteristics enables an additional mode in which the learner encounters the computer that is different enough from the other three modes to warrant separate consideration. The use of software that allows the learner to undergo the simulation of a real or imaginary experience, usually with the expectation that a problem-solving strategy or other insight will be acquired, does not usually cast the computer into the role of tutor. In the case of programs where the learner's options are limited (e.g. Hammurabi, Oregon Trail, and Odell Lake - type programs) the tutor case could be argued, but in other cases (the use of Logo microworlds and many games) the point is much harder to make. In most of these cases the learner does not teach the computer new procedures or rules, nor is the computer clearly a tool to be manipulated by the learner to serve his or her own ends. I believe that this concept cuts across Rushby's (1979) proposed *revelatory* (simulation) and *conjectural* (hypothesis-testing) modes (I would not propose two additional modes), and relates to Snyder & Palmer's (1986) description of the computer in the role of *modeling device*.

In keeping with Taylor's use of words that describe the computer's role, and wishing to preserve the alliterative appeal of his model, I spent about 20 minutes daisy-chaining with an electronic thesaurus (classic example of tool mode) looking for a fourth t-word with which to supplement Taylor's original three. The best that I could come up with is the term *tableau*: the computer as vivid, graphic domain to be encountered. I am not entirely satisfied with the term, mainly because it carries static connotations, but if it is fair to speak, as we educators do, of cognitive *domains*, then possibly it is fair to speak of cybernetic tableaus. I also know that many undergraduates will not recognize the word, but the next best choice was *tract*, which smacks of "ground" and "real estate" connotations (auguring a grisly prospect to the pilot of a flight simulator). At any rate, I invite the reader to find a better name.

Teacher Roles, or Terminology Related to What Teachers Can Do With Learners and Computers

Gaining knowledge of the characteristics of computer software and how those characteristics apply to the learner/computer interaction are only the first and second steps in articulating a comprehensive understanding of teaching and learning with computers. The third step is understanding the teacher's roles. In most of the texts reviewed here, teacher roles are only implied in the context of other discussions; they are rarely made explicit.

The only explicit language common to a majority of the texts is the teacher's use of the computer to manage tasks related to instruction (Willis, Johnson, & Dixon, 1983 is an especially rich source in this regard), most often called CMI (do not confuse this usage with the use of the same acronym as a substitute for "CAI".) A smaller number of the texts (Willis, Johnson, & Dixon, 1983; Dennis & Kansky, 1984; Bramble & Mason, 1985; Riedesel & Clements, 1985; Olson, 1988; Troutman & White, 1988) additionally devote themselves to the overt discussion of other teacher roles such as implementing the use of CAI in tutor mode, development of instructional materials, and group demonstrations. Only handful of them attempt to articulate a comprehensive model, and none is fully developed. Dennis & Kansky (1984), interestingly, pose a three-part model regarding teacher roles, and like Taylor before them choose to discuss it in terms of the computer's function: the computer as teacher, the computer as partner (motivation, decision-making, data manipulation), and the computer as aide-de-camp (CMI). Troutman & White (1988) also give us three terms for characterizing teacher roles, presenting them mostly in the context of categorizing software: computer-directed instruction (CDI), computer-enhanced instruction (CEI), and computer-managed instruction (CMI).

My examination of the work of others and re-examination of my own work leads me to propose the following model for teacher roles: teachers *direct*, *enhance*, and *manage* instruction. I borrow and redefine the terms offered by Troutman & White (1988) because I consider them applicable and accurate, and they can be phrased to relate instructional events in terms of teacher roles, not computer roles (it's a shame there's no alliteration, but I'm all thesaurused-out).

Directing Instruction

Teachers direct instruction when they relinquish to the computer the role of tutor, causing students to encounter computers in the tutor mode. Software possessing tutorial and drill characteristics is typically employed in this mode. Teachers must identify, develop or acquire, and evaluate appropriate software; create or acquire environments sufficient to allow learning to take place; implement the software at teachable moments, supervising its use and dealing with individual problems; and evaluate the mastery of objectives.

Enhancing Instruction

Teachers enhance instruction when they use the computer to develop or to implement instruction or instructional materials for the improvement of learning or teaching performances. Teachers use software with application, simulation, or problem-posing characteristics as tools to develop teaching and learning aids, to illustrate and demonstrate concepts, or to implement inductive mode or other experiences that engage learners in active, constructive ways. Learners are typically caused to encounter the computer in tutee or tool modes.

Managing Instruction

Teachers use computers to implement activities or materials peripheral to teaching and learning. Typical examples are: monitoring and incorporating into the overall evaluation scheme prescriptive analyses or reports of progress generated by courseware or integrated learning systems; and use of generic applications or custom software for attendance, record-keeping, test development and administration, evaluation and analysis, and decision-making.

If my statement of the *direction* function appears obvious, implied as it is in almost any discussion of CAI, consider that it is rarely discussed *explicitly*, or explicitly linked to the identification and description of activities conducted by the teacher to integrate the computer-based learning experience into the overall teaching process. The effective integration of software into teaching and learning is not obvious. Two particularly rich sources of information on the process are Roblyer (1989), who provides us with lesson plans designed around Gagne's (1985) events of instruction, and Collis (1988), whose text contains about 100 lesson plans demonstrating many different applications.

The statement of the *enhancement* of instruction incorporates an idea that appears in almost all of the texts reviewed; the teacher's use of computers to make transparencies, worksheets, and certificates. If it seems odd to include this in the same mode as the use of the computer with an LCD overhead projector panel to make classroom demonstrations, or the use of software with simulation characteristics to develop problem-solving competencies, or the use of word processing software to teach process writing; consider that each of these examples is an

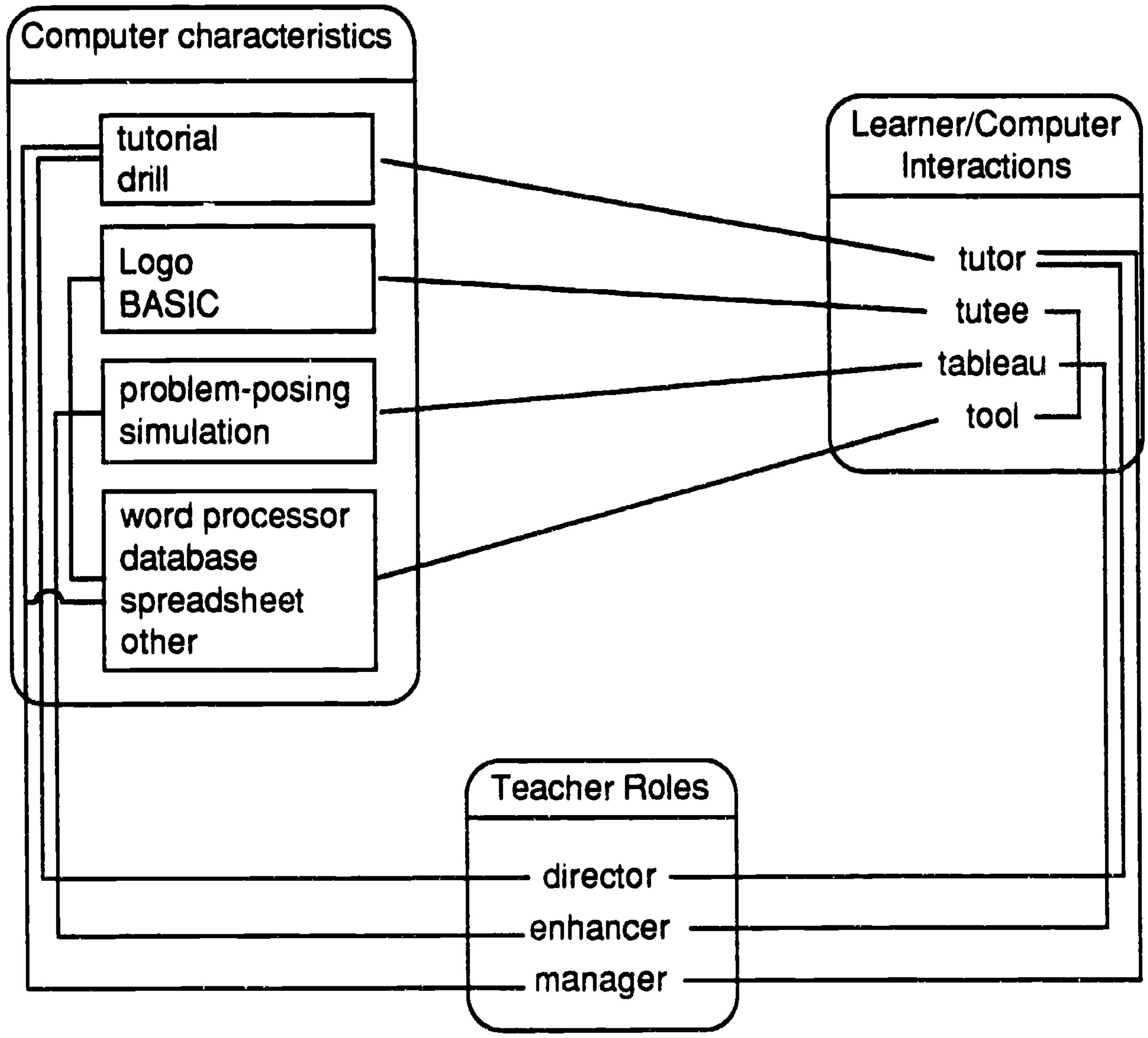

Figure 1. A Model for Conceptualizing Computer-Based Teaching.

activity that is implemented by the teacher with the assistance of the computer, and not the other way around.

Words of Caution Regarding Systems of Classification

In all human endeavors, we seek to classify, to organize, and to describe in order to better understand the phenomena with which we work. A characteristic of all systems of classification is that they are all flawed. There is always an event or thing that can be argued more than one way, even in the most rigorous and clear-cut of systems.

Such terms as problem-posing, simulation, and game have overlapping domains. Does the student's use of a simulation fall into tutor, tutee, or tool mode? Is the teacher's use of a computer-prepared overhead transparency that summarizes test results more an act of enhancing instruction or of managing instruction?. Try to get three experts to agree on exactly which of the levels of Bloom's (1956) cognitive taxonomy a given test item causes the learner to operate. Even in so clearly definitive a system as biology, there are organisms that do not wholly belong to either the plant or animal kingdoms.

Therefore, I have found that it is important to impress upon (remind) students that a system of classification is an attempt at *modeling* a thing ... but it is not the thing *itself*. Flaws, or failures in the system's ability to accurately describe given phenomena, do not automatically invalidate the system's usefulness in allowing us to think more clearly.

Conclusion

I caution the reader not to accept this work uncritically and I encourage its refinement. I offer these thoughts only in the following context: I have spent some time and effort in developing and articulating them, I have found them to be of value to my own understanding, and I believe that they have been of value to my immediate colleagues and students. I submit them for your consideration along with this diagram in which I attempt to graphically portray the major relationships discussed in the body of the paper.

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Technology in Preservice Teacher Education

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Teacher education programs in liberal arts universities contend with a crowded curriculum. Extensive liberal arts and state certification requirements leave little room for electives. This becomes a challenge when planning curriculum changes. Stetson University, a small liberal arts university located in central Florida, faced such a challenge when planning to include computer technology in the education curriculum

A survey revealed that all our education majors had some level of computer literacy; that is, they knew about computers. Many had interacted with computers, and most commonly, this interaction was competence in word processing. Our students were aware of educational games designed to help children learn. However, no student knew how to integrate courseware effectively into the curriculum. In fact, many were not aware of ways to use computers in the classroom. The education faculty quickly concluded our program was seriously lacking in preparing teachers to use computer technology in the classroom.

Developing a Rationale

As we considered what we wanted to achieve it was clear that adding a required course in technology was not feasible, nor would it achieve our goal of helping preservice teachers develop competence in teaching with computers. We felt that preservice teachers would be more apt to use computer technology in the classroom if they had multiple opportunities to use a wide range of software applications over time. Developing lessons in all content areas would make the theoretical practical. We concluded that integrating computer assignments into every course would accomplish our goal.

Initial Challenges

Our initial challenge was hardware acquisition. Three years ago Stetson committed funds to increase computer usage on campus. With the support of our department faculty, a proposal was written to the University-wide Computer Committee requesting three Apple IIGS computers and two printers. The proposal stated our willingness, as a faculty, to integrate computer assignments into all our elementary methods courses. We received the computers, and along with an IBM PC Jr. and an Apple IIe, we established a small computer lab dedicated to education majors.

There were other challenges. Now that we had the hardware, where should we begin? What software should we purchase with our limited resources? The education faculty had very little experience with computers. Much like the students, the faculty knew about computers and several had experience in word processing, but only two professors had any experience teaching with computers.

We began with a computer literacy module developed by the writers and used in our senior student teaching/ general methods block. The module contained a brief history of computers, computer vocabulary, common implementation concerns, computer uses in education, care of disks, copyright laws, software evaluation guidelines, and basic hands-on assignments. For example, the initial assignment requires students to Tour Your Apple IIGS. Other assignments include initializing a disk using instructions given in the module, and using a simple word processing program to hard copy a one page summary of what they learned about computers in the schools. The module also includes a form for evaluating courseware. We selected user friendly products for the students to evaluate. Faculty members could review the computer module or other software in private faculty review sessions.

During the initial semester, an assignment in the reading diagnosis course required the students to determine the readability level of trade books and to develop cloze paragraphs for reading assessments. After an initial experience of doing these tedious, time consuming tasks by hand, the students welcomed the time saving, user-friendly computer assignment.

Our next challenge was getting a computer assignment into every course in an effective manner when the faculty was (1) still very inexperienced, (2) had little understanding of ways to use a computer in the classroom, and (3) had no background for courseware selection. To overcome these or similar challenges, it takes at least one knowledgeable colleague who is willing to help the faculty through the initial hurdles. That became the lead author's challenge.

In a department meeting we discussed the different ways to use computers in our disciplines. Then the task was to find at least one piece of software appropriate for use in each of the methods courses. The programs had to be user-friendly and approved by an educational software review, such as those that appear in computer magazines. We also looked for software that had support materials, since our goal was to have the preservice teachers prepare lessons that would integrate courseware programs.

Implementation - Phase One

The faculty quickly developed expertise in using the software selected for their courses. The following uses emerged:

Language Arts Block	word processing program
Initial Reading Course	Writing to Read Software drill and practice through game-like programs
Advanced Reading Course	readability program, cloze technique program
Social Studies Methods	simulations, data bases
Science Methods	tool kit experiments
Math Methods	drill and practice facts, time, money
Early Childhood	educational games
Intro To Exceptional Students	Structure of the Intellect (SOI) management program

All elementary schools in Volusia County, where Stetson University is located, use the Writing to Read software; thus, making it our choice for preservice teachers in the initial reading course. Without this influencing factor our recommendation would be tutorial and drill and practice for an initial reading course. A professor's interest, likewise, made the SOI a unique choice for our exceptional student education course. Otherwise, our recommendation would be thinking skills software and a printer utility program such as Print Shop. These applications were available in the lab, although not used in these courses, during the first year.

Phase Two

This year we entered phase two of our plan. Students enrolled in the above courses used the assigned software. The computer module initially introduced in the student teaching/general methods course is now in EN 265 - Principles of Instruction, a sophomore course. We continue to offer the computer module in our student teaching/general methods course for students in transition.

Our student association, Future Florida Educators Association (FFEA), devoted a meeting to computers in education. The meeting featured Broderbund's Carmen San Diego series. We extended permission for members of FFEA to use our education lab to enjoy any software we have available.

Phase Three

Next year we will be in the final phase of our implementation plan. We plan to add teacher utility software in the general methods/student teaching block to give our interns experience in grade book and lesson planning software. In addition, we will add Logo to the math methods course. Social Studies classes will increase experiences with data bases by building their own data bases.

During this phase we plan to reach out to our liberal arts colleagues who teach the secondary methods courses and encourage them to include a computer hands-on assignment for secondary teaching majors. Science tool kits, social studies databases, and word processing are capable of a wide range of sophistication and would be appropriate for secondary methods courses.

Anticipated Challenges

We will face new challenges. As instructors become more knowledgeable and want to use additional software, spending our limited funds will become an increased challenge.

We anticipate that increased demand for lab time will prove our small lab to be woefully inadequate. Fortunately, the development of new open computer labs over the last few years will ease this challenge. These labs are equipped with IBM and Macintosh machines. As courseware increases for the IBM and Macintosh computers, we plan to meet this challenge by purchasing software for these machines. We will encourage our students to use the general purpose campus labs as well as our small Apple lab.

What We Have Learned

1. It takes a minimal time commitment for a colleague to develop computer expertise sufficient to introduce a computer assignment into a course. Given friendly, stimulating software, the students quickly develop very creative lesson plans that include computer interaction.
2. It is helpful to purchase software that includes supplemental classroom suggestions or teachers' manuals, which provide preservice teachers with a springboard for their lesson plans. We found that Minnesota Educational Computing Consortium (MECC) software meets this need in most cases.
3. Start simply. Learn one application and purchase two or three programs in that application. For example, there are several excellent data base programs on the market in social studies. Some, such as the MECC Dataquest products, can revise, update or build databases. As the students gain competency, add different applications to their assignments.
4. Check with your local public schools for suggestions as you begin selecting software. In our case, the Writing to Read software was ideal for our students because of its extensive use in Volusia County elementary schools. Also, our choice of Bank Street Writer as our word processing package complemented what the public schools in our locale were using.
5. Read the software reviews in magazines such as Electronic Learning, Media & Methods, or Classroom Computer Learning for recommendations. Check the software ads for awards given to the software.
6. Don't delay implementation waiting for the perfect courseware. The goal of helping teachers use the computer to support their curriculum is possible with the software that is already on the market and that, for this purpose, will not be come outdated in the near future.

Predictions for the Future

We anticipate that our students will begin to view the use of computers in the classroom as an essential tool to help them teach and to help students learn. They will think of computer assignments as naturally as they now think of a book or paper and pencil assignment.

Long range goals will deal with introducing our staff and students to multimedia such as laser disks and CD-ROM devices interfaced with computers. At the 11th Annual Florida Educational Technology Conference held in Tampa, February, 1991, Florida Education Commissioner Betty Castor announced that money was appropriated recently to ensure that each school in Florida will have at least one laser disk by the end of this school year. So for us, the future is now.

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Curriculum Integration Project: An Evolving Model

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Introduction

Technology education has been designated as a priority in the teacher education program at the Center for Excellence in Education at Northern Arizona University (CEE). According to the federal government's Office of Technology Assessment, only 28 percent of new teachers feel prepared to teach with computers when they enter the classroom. Half of all teachers believe their students know more about computers than they do (Gursky, 1991). School systems often buy computers and software, but fail to provide adequate inservice training. New teachers will not always receive technology training from their employers. Fewer than 20 states, however, require technology training for education students.

CEE, a teacher preparation department at Northern Arizona University, sent out a call for help in planning technology education for their future teachers. Education faculty voted as a group to integrate technology into their existing curriculum, rather than to add on extra classes for their education students. CEE's first step was to hire someone to help make this integration possible. My assignment, as Assistant Professor of Educational Computing and Technology, is to teach two sections of an existing computers in education course, with half-time designated for faculty development. CEE's technology integration plan is in its beginning stages and is constantly evolving. Problems are inherent in the evolution of such a program. This paper will address those problems, as well as the steps that CEE is taking to develop a plan for their education students that fits the goals of an integrated curriculum. CEE and this writer hope that a sharing network will result from the 1991 Technology and Teacher Education Conference and the formation of a new national organization.

An Integrated Technology Plan

Faculty at CEE decided collectively that technology courses would not be added on to the already crowded teacher education curriculum. Instead, technology education would be integrated into existing courses. That conviction led CEE to plan for an integrated computer and technology program. The faculty has agreed that technology must go beyond the computer, but has chosen to concentrate on the computer for productivity and instruction during the initial phases of the integrated technology plan.

Background

In the past, a few faculty members at CEE brought whole classes to the computer lab several times each semester for software demonstration. This kind of computer extravaganza seemed to perpetuate the typical out-of-context approach used in many elementary and secondary schools: "Put everything away, it's computer time." Other faculty members ignored computer instruction or demonstration in their content area completely because of a lack of personal knowledge of the computer, or because it was convenient to exclude the topic from an already full course syllabus. The CEE realized that a different model was needed in the teacher education program. The model discussed here is based on the premises that (1) the computer should not be an object of study in itself but a tool to make instruction more effective in established curriculum areas, and (2) computer use should be consistent with whole-class instructional organization. It was with this background and knowledge that a computer integration plan was formed. First, a scenario created from our vision is presented.

Scenario: A Vision

Students are seated in four large groups, their desks arranged around one desk holding reference materials: almanacs, maps, dictionaries, encyclopedias, and pads of paper. Today's session of A content area reading class at CEE is being team taught by a reading professor and a computers in education professor. The topic is "teaching reading strategies." A computer program, *Where in the World is Carmen San Diego* (Portwood & Elliott, 1985) by Broderbund, is projected on the white screen at the front of the room. All the equipment needed by these instructors is on a portable cart that is custom built for the hardware needed for this type of demonstration. This cart and hardware is usually housed in the computer room downstairs, but an elevator and the rolling cart provide easy access to the large lecture room. Together, the instructors demonstrate questioning strategies by Rafael (1986). Right There, Think and Search, and On My Own as the students investigate a stolen treasure. Question Answer Relationships (QAR's) help students realize the need to consider both information in the text they are reading and their own background knowledge. Rafael suggests that middle school students benefit from extensive use of this category system by considering text structures. In this scenario, groups of education students use reference materials to find information that will lead them to their next destination in the software simulation, but at the same time the students are encouraged to determine and to discuss what kind of question they are asking themselves as they read the information provided on the screen and in their reference materials. Ultimately, these future teachers are previewing software, making critical judgements on the software's support in a reading classroom, and are watching computer integration modeled in a content area classroom. As this session comes to a close, students are assigned a project that will give them practice in integrating reading instruction, commercial software, and a content area of their choosing. Several students are heard discussing software they previewed in another course that might support reading in science. The portable computer station is rolled into another classroom down the hall, where a group of students in a science methods class has prepared a multimedia presentation using interactive laser disks and *HyperCard* (Apple, 1988).

Phase One

The CEE set two major themes, or emphases, for the 1990-1991 school year: technology education and Native American education. At the annual Advance meeting held at the beginning of the year, each departmental area (Educational Specialties, Educational Leadership, Instructional Leadership, etc.) concentrated on these two themes as they planned goals and objectives within department areas. Individual group goals were combined and discussed in large group sessions, giving the technology plan a definite direction.

Teachers, whether in an elementary, secondary, or higher education setting, must feel a personal need for computer use in their classrooms before they will be convinced that they should include computers and related technology in their curricula. Having faculty use computers for their own productivity was the first phase of CEE's technology integration plan. To do that, it was felt that faculty members should have computers on their desks. The administration supported this idea and Macintosh SE's with hard drives were purchased for each faculty member who agreed to take one! At the present time, eighty-nine percent of all faculty members have a Macintosh (forty-nine) or IBM (eight) computer in their office, with networked access to application software from a server. Of the seven remaining faculty, one uses his own PC, while another uses a Macintosh in an on-site Program at an elementary school. Also available to the faculty is a work room with two Macintosh computers and software access. All computers can print to designated laser printers located throughout the building. Most users have access to an electronic mail program which allows for easy communication between offices, and in some cases, between buildings. Faculty can also communicate by BITNET, but the system seems to be laborious for those beginning with computers, and only a few are using BITNET at this time.

As money becomes available for hardware purchases, CEE's plan is to replace Macintosh SE's (with hard drives) in the computer lab with Macintosh LC's. The Macintosh SE computers will be placed in faculty offices to replace a few remaining Macintosh Plus computers and those Macintosh computers with external drives.

Phase Two

Now that most faculty have access to a computer, the next stage of the plan is to provide staff training. A survey of faculty conducted by the Faculty Development Task

Force indicated that workshops were needed in several areas. Interest was expressed for an introduction to Macintosh, beginning and advanced training on a word processor, and using the computer as a presentation tool. One hour workshops were scheduled to first introduce the Macintosh, then beginning and intermediate word processing were added and repeated as those faculty members just beginning to use the computer became more practiced and confident. Individual faculty are also able to get help for specific needs or one-on-one training with the Educational Computing and Technology faculty member.

Where Are We?

Starting in the spring semester of 1991, all willing faculty members at CEE are involved in planning for computer integration with the Educational Computing and Technology faculty member. This planning involves sharing information concerning course content and available software that supports that content. As areas of possible technology-supported content are identified, plans are being made to include demonstration within the context of the content area classroom, with whole group instruction. This is possible through the use of portable teacher demonstration stations.

A portable teacher demonstration station consists of a rolling cart that is outfitted with a low heat overhead projector, an LCD projection device, a computer (available for IBM, Apple IIGS, or Macintosh computers), and a printer. These portable stations can bring about integration into existing curriculum and within the context of the classroom, rather than one-shot sessions that present the technology in an isolated fashion. As funds become available, other technology such as interactive laser disk and CD-ROM players will be added to the teacher demonstration stations. These stations provide education students with a view of existing technology integrated into their methods classrooms in a model that can be used in elementary and secondary classrooms. Education faculty are involved in technology demonstrations through the support of the Educational Computing and Technology faculty member, who bridges the gap between content areas and hardware and software available for that subject.

Problem

Problems encountered, as might be expected, are interfering with the smooth progress of the CEE's integration plan. For example, despite the fact that technology has been given a high priority at the Center, revenues for higher education have been cut drastically in Arizona and money has not been made available for equipment as expected. The outlook for next year appears just as bleak. Grant writing has become imperative if we want to create mobile teaching stations. Wait time involved, as well as the gamble of grant proposal acceptance, has almost halted this integration plan in its beginning stages, at least with regards to equipment and software.

On a Positive Note

The plan itself is still in action and is gaining momentum as we use the limited equipment and software available to us. Faculty have not let the lack of portable computer stations keep them from using the human resources available. Education classes are brought to the computer lab and an LCD projection device is used to demonstrate software as closely as possible within the context of a content area. Reading strategies are demonstrated with a geography program and, while it is not the optimal situation, students can still see the computer integrated in a somewhat limited fashion.

What is exciting to this writer is that requests for help to include computer objectives into education courses are increasing, and it is difficult to find unscheduled time in the computer lab as instructors are reserving the lab to demonstrate software, or in some cases, to teach students a computer application. Several faculty members are now requiring students to use a word processor for research papers, and students must go through a checkoff procedure with the Educational Computing and Technology instructor. Those new to word processing attend a workshop series scheduled immediately before their education class. One such class, Introduction to Special Education, is an Interactive Television Distance Education class, with part of the class attending at a site in Yuma, Arizona. Even the distance between Flagstaff and Yuma was not enough to prohibit this requirement, as faculty from both sites worked out an arrangement for checking off and instructing students. The technology integration plan at the Center for Excellence in Education at Northern Arizona University is still evolving, and as we face one obstacle after another, the plan is flexible enough to allow us to continue with our vision.

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Videodisk-Based Science Training of Elementary Preservice Teachers: Transfer Effects to Classroom Settings

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Qualitative and quantitative deficits in elementary science programs have been well documented in the literature for the past two decades (Haury, 1989; Mullis & Jenkins, 1988; Stefanich & Kelsey, 1989). Perhaps the most frequently cited problem is the lack of adequate science content knowledge on the part of both experienced (Morey, 1990) and beginning (Tilgner, 1990) elementary teachers. One suggested explanation for this problem (Benson & Yeany, 1986; Stefanich & Kelsey, 1989) is that out-of-college science electives taken by undergraduate preservice teachers lack the instructional formats needed to build the meaningful student understanding that provides a foundation applicable to science teaching in school settings.

In recent years, a number of researchers (Benson & Yeany, 1986; Stefanich & Kelsey, 1989) have shown the actual or perceived performance of preservice teachers in science content courses can directly influence their attitudes toward science and science teaching. These findings are also consistent with a growing body of literature indicating that perceived control over classroom situations involving science teaching (i.e., science locus of control) is strongly related to attitudes, aspirations, and anxiety toward teaching in general and toward teaching science in particular (Bar-Tal, Kfir, Bar-Zohar & Chen, 1980; Haury, 1989).

Recent perspectives from cognitive science (Resnick, 1989) not only support the importance of providing preservice elementary teachers with science knowledge, but imply even more strongly that such knowledge must complement (or be integrated with) science methods courses if they are to be effective. In support of instructional guidelines for methods courses suggested by Benson & Yeany (1986), a number of studies have shown that improvement in the content and relevance of science content courses could significantly enhance positive attitudes and reduce anxiety about science and science teaching in undergraduate preservice teachers (Benson & Yeany, 1986; Romance & Vitale, 1989, 1991; Stefanich & Kelsey, 1989). Yet, at the same time, none of these studies has specifically addressed the problem of how specific forms of science knowledge can be integrated with different forms of science teaching pedagogy (e.g., Duschl, 1980), nor the follow-up effects of doing so upon preservice teachers' subsequent attitudes toward science and the extent to which they perceive themselves as being in control of science teaching in classroom situations after they have obtained direct classroom teaching experience.

With the preceding in mind, the present study integrated videodisk-based core science concept instruction within a traditional elementary science methods course in order to determine its influence upon the affective perceptions of the participants at the end of their student teaching experience. In doing so, the study used scales developed by Haury (1989) to determine the effect of the modified methods course upon different facets of preservice teachers' attitudes toward teaching science (supportiveness/importance, aspirations, anxiety) and their self-perceived locus of control (internal vs external) in teaching science.

Method

Subjects

The 19 experimental and 43 control subjects were preservice elementary teachers who were surveyed during the last 4 weeks of their student teaching experience. Each participant had previously completed one of two randomly-assigned versions of a one-semester science methods courses in the College of Education: (a) an experimental version using videodisk-based instruction to foster in-depth understanding of physical and earth science or (b) a control version that included a general survey of science content.

Instrumentation

Affective perceptions were measured by a combined 48-item Likert Scale, "Your Thoughts About Science and Science Teaching," developed by Haury (1989), consisting of three "Expressed Attitudes Toward Teaching Science (EATTS)" scales: "EATTS-I," supportiveness of the importance of science instruction; "EATTS-A," aspirations toward science teaching; "EATTS-RA," reduced anxiety toward science teaching; and a fourth scale, "Locus of Control in Science Teaching (LOCIS)." Previous research had shown that each of the instruments has high internal consistency reliability, with a Cronbach's "alpha" reported by Haury (1989) of .82, .86, .85, and .74 for the EATTS-I, EATTS-A, EATTS-RA, and LOCIS scales, respectively.

Experimental Science Methods Treatment

Both the experimental and control versions of the science methods course followed the same syllabus but differed in how they utilized the time during which science knowledge was addressed. The control class explored a wide variety of science concepts in conjunction with hands-on science process activities within the context of learning science teaching methods. In contrast, the experimental group focused on the intuitive mastery of physical science core concepts such as heating/cooling, force, density and pressure as applied to earth science (e.g., solid earth, atmosphere, oceans). These concepts were taught through videodisk-based portions of a commercially-available instructional program, "Core Concepts in Earth Science" (Hofmeister, Engelmann, & Carnine, 1989), in conjunction with supporting hands-on process-oriented science activities during the semester-long course.

Follow Up Survey Procedure

All participants completed student teaching within two semesters after completion of their science methods course. Assignment of preservice teachers to elementary school sites was made by the College of Education student teaching Director without any knowledge of students' previous science methods course. The experimenters distributed the survey instrument directly to participants through their supervising teachers. Participants mailed their responses to the experimenters using the stamped/addressed envelope provided. Data were analyzed using SYSTAT software (Wilkinson, 1987) on an IBM AT-compatible microcomputer.

Results

Table 1 presents the mean differences for the experimental and control groups on the four affective scales, EATTS-I, EATTS-A, EATTS-RA, and LOCIS. As Table 1 also shows, significant differences in favor of the experimental group receiving the videodisk-based core concept lessons were found on each of the three EATTS science attitude scales. Although not significant, the mean difference on internal locus of control in science teaching (LOCIS) was consistent with the pattern of differences on the set of criterion measures.

As Figure 1 shows, using the percent of the maximum possible score, the mean responses on the four affective measures for both the experimental and control groups were ordered from most to least positive as follows: supportiveness of the importance of science instruction (EATTS-I), aspirations for science teaching (EATTS-A), reduced anxiety associated with science teaching (EATTS-RA), and internal locus of control in science teaching (LOCIS).

Discussion and Conclusions

The present study extended previous findings by Romance & Vitale (1991) by showing that the videodisk-based science concept instruction could establish a stable positive orientation toward the teaching of elementary science as measured by the three EATTS attitude scales that would transfer from end-of-course perceptions to subsequent classroom teaching experiences during student teaching. These findings are supported by Benson & Yeany (1986) and Stefanich & Kelsey (1989) who found that increased knowledge and understanding in science improved preservice teachers achievement in science as well as affective measures relative to the teaching of science. Other previous results reported by Romance & Vitale (1989) using different instruments in conjunction with videodisk-based instruction also have shown the importance of science knowledge in improving

Table 1

Mean Differences Between Experimental and Control Groups

Criterion Measure		Group Exp.[a]	Group Cont.[b]	E-C Diff.	Obtained t value[c]
Support for importance	m	37.74	34.02	3.72	3.82*
of science instruction	sd	2.62	3.86		
("EATTS-I")					
Positive aspirations for	m	35.84	31.05	4.79	4.05*
teaching science ("EATTS-A")	sd	3.27	4.67		
Reduced anxiety regarding	m	35.58	31.21	4.37	3.46*
science teaching ("EATTS-RA")	sd	4.00		4.81	
Internal (vs external)	m	51.42	48.79	2.63	1.68
locus of control in	sd	6.16	5.49		
science teaching ("LOCIS")					

[a]"n"=19
[b]"n"=43
[c]"df"=60
*"p" < .05

preservice teachers' attitude and confidence toward science teaching.

Implications of the present study also are consistent with the findings of researchers who advocate the integration of content with methods for more effective teaching (Shulman, 1990) and suggestive of a cognitive science based (Anderson, 1982; 1987; Resnick, 1989) methodology for addressing more complex issues in teacher education, in general, and in science education, in particular. However, by way of contrast with some related research (Bar-Tal, Kfir, Bar-Zohar & Chen, 1980; Haury, 1989), this study found no relationship between locus of control and the increased science understanding engendered by the videodisk-based treatment. With this in mind, a key future research priority is to investigate the effects of integrating science knowledge and science pedagogy in science methods courses upon observed classroom teaching proficiency in science and teachers' associated affective perceptions. If such relationships can be established, then the role of in-depth understanding of science knowledge in determining teachers' affective response toward science instruction in context of their perceptions of their own control over their effectiveness as science teachers can be explained directly.

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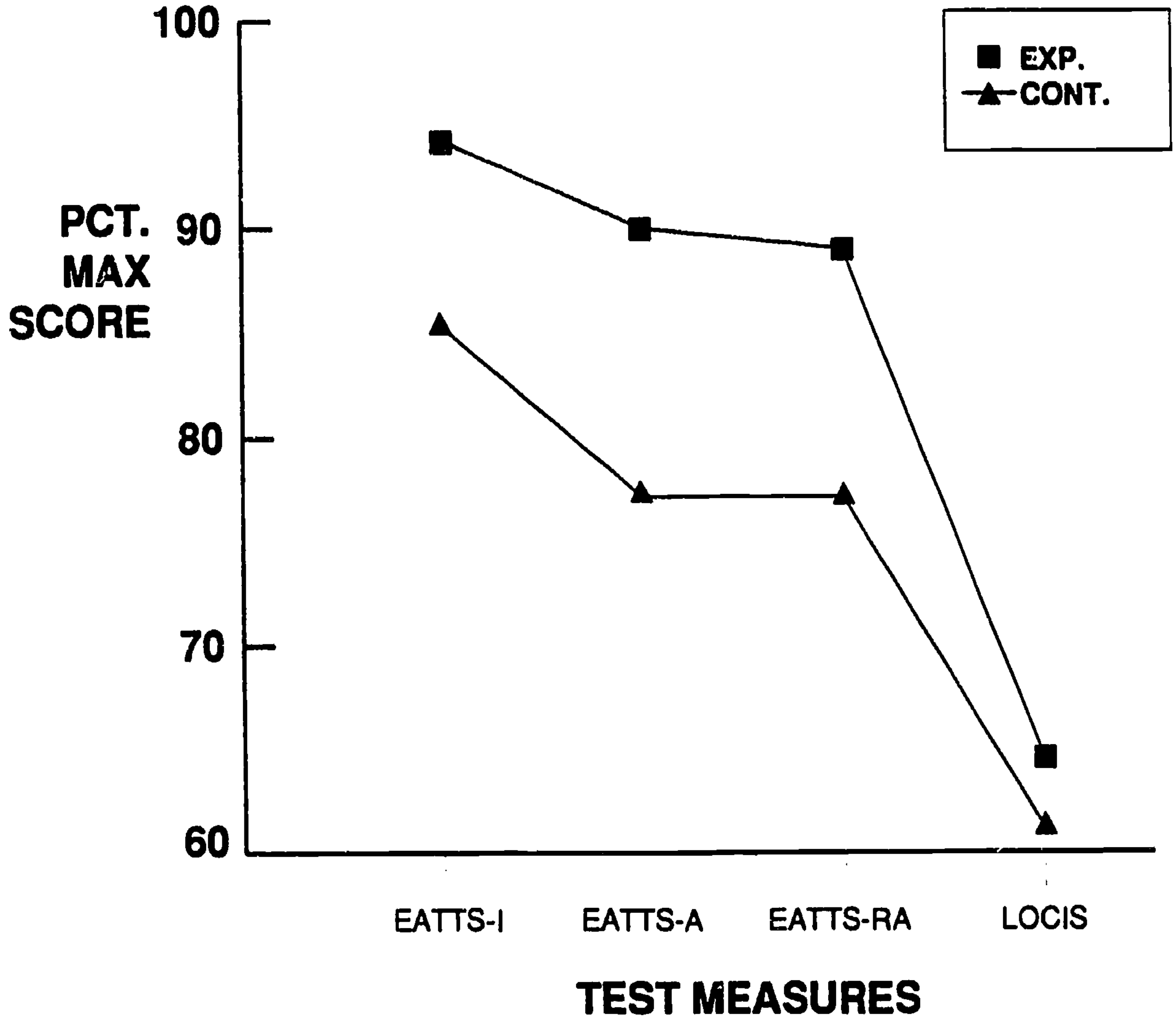

Figure 1. Percent-of-maximum scores for the experimental ("EXP.") and control ("CONT.") groups on the criterion measures: Support for importance of science instruction ("EATTS-I"), Positive aspirations for teaching science ("EATTS-A"), Reduced anxiety regarding science teaching ("EATTS-RA"), Internal (vs external) locus of control in science teaching ("LOCIS").

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Rethinking and Redesigning the Technology Experience For Professional Teacher Education Students at the University of Northern Colorado

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Introduction

In a recent survey conducted by the American Association of Colleges for Teacher Education, faculty and students in 90 of its member institutions were asked to evaluate the effectiveness of their teacher education programs. Ten of the twelve aspects covered by the survey received favorable results. Technology preparation received a flunking grade (Fulton, 1989).

The Office of Technology Assessment reported that interactive technologies have tremendous potential in education. The report also suggested that, while most teachers want to use these technologies, they do not feel adequately prepared (Gooler, 1989). One researcher stated that the integration of technology into the teacher preparation curriculum *is the single most pervading issue in colleges of education today relative to technology* (Bitter & Yohe, 1989, p.22).

In order to confront this issue, the educational technology (ET) faculty and graduate students at the University of Northern Colorado (UNC) undertook a major project aimed at redesigning its basic undergraduate educational technology course, ET 401. The ET faculty subscribe to the notion that preservice programs, unlike inservice programs, can provide future educators with the amount of instruction required to successfully integrate and apply technology in the classroom (Bitter & Yohe, 1989).

Goals of the ET 401 Redesign Project

Major course redesign began at the start of the spring semester, 1990. The following goals provided the foundation upon which ET 401 was built:

1. Teachers must be proficient, critical users of current educational technologies.
2. Teachers need a broad education in order to determine the applications of changes and innovations in technology from more than one perspective.
3. Teachers must be competent designers of instructional systems that assist in the development of critical thinkers (Bitter & Yohe, 1989, p. 23).

In addition to those general goals, specific guidelines about the teaching/learning process were also developed: (a) students must engage in relevant experiences with technology in ET 401; (b) ET 401 instructors must model a variety of innovative teaching strategies making use of appropriate technology; (c) students must engage in hands-on projects whenever possible; (d) because of the variety of ability levels and experiences among teacher education students, choices of projects, workshops, and assignments should be provided that cover different ability levels and interest areas (Heinich, Molenda, & Russell, 1989).

Several formidable challenges had direct impact on course redesign. Typically, between 200 and 250 students are enrolled in four sections of ET 401. Dealing with such numbers required creative scheduling and teaching in order to adhere to the goals and guidelines identified. Also, the course carries only two semester hours of credit; consequently, the work load and time requirements had to reflect this limitation.

A research project was launched simultaneously with commencement of the redesign project. The idea was to determine what areas of instruction in the current ET 401 offering were effective, and what needed to be added, modified, or eliminated. Students were given a questionnaire and were asked to report on how well prepared they felt in various technologies after completing ET 401. The technologies included various computer applications, as well as E-mail, telecommunications, film and video, projected and non-projected media including equipment operation, bulletin boards, and chalk boards. Additionally, they were asked to report how important they felt these technologies were. In general, most students who completed the questionnaire reported that they felt computer technologies were very important, but they were not well prepared. This is consistent with the OTA report mentioned earlier (Gooler, 1989).

Teacher education students felt generally well prepared in the use of nonprojected media, equipment operation, and integration of film and video into the curriculum; furthermore they felt that all three were important. They did not feel that E-mail or telecommunications (including Whittle's Channel One, Tie-In, etc.) were important topics, nor did they feel well prepared to integrate these topics into their teaching.

Implications for Course Redesign

Based on the goals, guidelines, challenges/limitations, and data gathered from the questionnaire, ET 401 was totally revamped. Major redesign focused on integrating computer skills with other technologies in order to reach instructional goals. For example, a CD-ROM project has been added in order to get students involved in the literature associated with technology in their fields, and to teach them how to conduct electronic searches using a microcomputer/CD-ROM unit.

Another example of integrating computer technology with more traditional media is an assignment covering the production of overhead transparencies in which students are required to incorporate computer graphics. Optional workshops are offered on application packages such as MacPaint and MacDraw for those students who require such instruction.

As part of the course requirements, students must participate in computer workshops, but they can choose from a variety of options including basic word processing, teacher utilities, educational courseware, desktop publishing, and so on. In this way, ET 401 can meet the needs of various ability levels and areas of interest. Class time is devoted to issues surrounding the integration of the technologies learned in the workshops, and developing an awareness of the uses of technologies that students feel are unimportant, such as E-mail and telecommunications. Students also participate in workshops devoted to non-computer based media, including video production, and A-V equipment operation.

Redesigning and rethinking the technology experience for teacher education students is a positive step toward preparing teachers in the use and integration of technology in the classroom. However, ET 401 is still far from perfect. Students often feel uncomfortable with certain technologies. This can create a certain amount of anxiety and confusion resulting in additional work for the GA's and instructors. Also, the nontraditional format of the class—workshops and projects rather than lectures and tests—can be uncomfortable for many students. Again, extra care is required to monitor student progress.

In general, ET 401 is a project oriented class that stresses student involvement with technology. However, given the rapidly changing nature of technology, the ET faculty recognizes that teaching students which buttons to push on a machine or which commands to enter to operate a computer program should not be the focus of the course. As one researcher stated: "The job of the undergraduate program is to make sure the students have a basic handle on the technology. Given the rapid changes in technology and the limited time in undergraduate study, we need to make sure these individuals are prepared to recognize the significance of technology, to realize that it's part of life, so they can update skills throughout their careers" (Bruder, 1989, p. 35).

In order to work toward this end, the projects in ET 401 are designed to foster success so that students will develop positive attitudes about technology in the hopes that they will continue to embrace innovation.

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Never Perfection, But Always Toward It: One Model For Computers In Education

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Approximately eight years ago, the Woodring College of Education (WCE) mandated that all graduate and undergraduate students be computer competent before graduating with their degree and/or certification.

Any student graduating in education should be comfortable in the use of computer technology and should understand its role in the classroom. Four goal statements and competency tasks were developed for WCE:

1. The student should be self-sufficient in the use of computer technology. Thus, the student will be able to operate a computer properly and run a piece of Computer Assisted Instruction (CAI) software that has bee[illegible] rovided. *You will demonstrate that you can "boot" a microcomputer and run a CAI progra[illegible]m a disk provided by our lab.*
2. The student should be aware of how the computer works. Thus, the student will be able to identify component parts of the computer and recognize the role of programming. *You will take a written test on the computer components and types of languages/ software used in education, and identify parts of a computer system.*
3. The student should be able to use computer technology as a tool to solve problems. Thus, the student will be able to utilize the computer as a "tool" to produce a product. *You will use a word processor to compose a document. You will also write a "short" program in a computer language of your choice.*
4. The student should be able to use computer technology in education. Thus, the student will be able to identify the type of software used in education and evaluate such software. *You will review ten (10) pieces of software using at least four (4) different brands of microcomputers.*

Three methods of achieving computer competency were developed: 1) passing a competency test which is given once each quarter, 2) satisfactory completion of a one credit course with scheduled tutorials, or 3) satisfactory completion of a major undergraduate or graduate course in computer education. *The College of Education strongly recommends the latter option.*

To successfully teach these courses a number of facilities were developed. The WCE presently has the following three computer labs: an IBM, a Macintosh and an Apple IIe. It also has a multimedia lab and an instructional technology lab. The heart for these labs is the Computer Demonstration Center (CDC) which houses a number of other types of individual computers. The CDC also has a large section of software, including most of the MECC software, much award winning software and a select number of public domain software.

There are approximately eight (8) assignments in the undergraduate course, including knowing how to word process a report, set up a grade book, and design a classroom database using Apple Works and/or Microsoft Works. The students must also write a simple program in Logo and BASIC. A major assignment is the evaluation of ten (10) software reviews which must include four (4) different computers, appropriate to the student's teaching area, and should include both elementary and secondary software regardless of the student's intended teaching level.

Other courses are available to students who wish to further their computer education. These courses include:

1. COMPUTER PROGRAMMING PROCEDURES (3 credits) An introduction to the basic elements of computer program design and classroom instruction.
2. EDUCATIONAL USES OF MICROCOMPUTERS (3) The study of software and planning strategies for the integration of computers into schools and classrooms.
3. APPLICATION SOFTWARE FOR EDUCATORS (3) Examines the use of word processing, data base management, spreadsheet analysis and other types of computer applications by educators.
4. INTERACTIVE SYSTEMS (3) An introductory study of interactive systems in educational settings; includes videodiscs/microcomputer interface, CD-ROM, and database services.
5. PRACTICUM IN EDUCATIONAL MICROCOMPUTERS (1-6) Supervised practicum for students to work in the design implementation and evaluation of microcomputer-based activities with selected K-12 population.

WCE has four (4) master's programs (elementary, two secondary and administration) which have an emphasis in computers in education ,while a fifth master's under development will deal with computers in industrial training.

Evaluation of the computer competency program is still underway; however, early research seems to indicate positive attitudes and evaluations by students who take the regular course in computer usage compared to those that challenge or take the one credit course.

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Technology and the Integrated Language Arts Curriculum, K-8

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The Integrated Language Arts

Knowledgeable of the body of research which supports a wholistic orientation to language arts education, teachers at the elementary and middle school levels are becoming increasingly more confident in teaching language arts in an integrated mode (Weaver, 1988). In reflecting on the implications of this research for teaching, they are finding that research in literacy development seems to support the use of strategies which include active engagement of students in meaningful experiences of thinking, listening, discussing, reading, and writing (Goodman, 1986; Holdaway, 1979; Atwerger, Edelsky, and Flores, 1987; and Heald-Taylor, 1989).

Some strategies of teaching and learning consistent with integrated language arts instruction include the following: a) immersion of students in language through reading, writing, and being read to; b) employment of literature-based strategic reading, using authentic texts for authentic purposes; c) integration of reading and writing; d) development of thematic units across the curriculum; and e) utilization of hypermedia in literacy development (Roos, 1990).

This author has reviewed courseware in the language arts in terms of these five emphases. Specifically, it is the purpose of this paper to identify microcomputer programs consistent with the goals of wholistic instruction. The following is a description of selected courseware that is supportive of integrated literacy theory.

Courseware and Integrated Literacy Development

Program: HYPERSTUDIO 2.1
Publisher: Roger Wagner
Grade: 1-Adult
Hardware: Apple II GS
Price: $149.95
Abstract: HYPERSTUDIO makes hypermedia (text, graphics, sound, animation, interactive video, and telecomputing) available. It supports Edmark's TOUCH WINDOW, Computer Eyes's VIDEO DIGITIZER, Apple II's VIDEO OVERLAY CARD, and Pioneer's 2200, 4200,8000 Laser Disk Player. Version 2.1 includes improved painting and editing tools, as well as four disks of clip art accessories. Advanced features comprise availability of additional hyperstacks on online services such as America Online, CompuServe, Genie, and from magazines such as Stack Central and the Hyperlearning Forum. This tool enables teachers and students to create multimedia data bases/stacks in the content areas. It empowers students to hear their own voices and to incorporate text, graphics, sound, animation, interactive video and telecomputing in their projects.

Program: LINKWAY
Publisher: IBM
Grade: 1-Adult
Hardware: MS-DOS, 512K
Price: $565
Abstract: LINKWAY makes hypermedia (text, graphics, music, speech, animation, interactive video, telecomputing, and more) available in associative, nonlinear ways. It allows teachers and students to create their own multimedia presentations combining text, graphics, picture images, voice and motion video. LINKWAY supports an IBM Speech Adapter, IBM Music Feature and a video disc player.

Program: SLIDE SHOP
Publisher: Scholastic, Inc.
Grade: 4-12
Hardware: Apple II Series, MS-DOS
Price: $69.95
Abstract: SLIDE SHOP is versatile, multimedia courseware which enables teachers to create interactive computer "slide" presentations. With it, students can create audiovisual reports, animated greeting cards, or letters that friends can run/self boot on their own computers. This program allows students to design their show, choosing from a variety of templates, backgrounds, fonts, and clip art. Color, sound, music, and special visual effects can be added. Screens can be printed onto overhead transparencies and printouts of screens can be made in color or black and white. Presentations can be captured on videotape and title sequences can be spliced/overlaid onto full-motion video by Apple II Video Overlay Card.

Program: BOOKWHIZ
Publisher: Educational Testing Service
Grade: 6-9
Hardware: Apple II Series
Price: $150.00
Abstract: BOOKWHIZ is an annotated database of about 1000 books designed to be used by students in book selection. The set consists of nine color-coded disks from which students might select in terms of book length, reading level, grade level, and gender of the main character. BOOKWHIZ searches the disk and indicates the number of books found meeting the desired book's specifications. A two-line teaser, a ten line annotation about the book, or the option to list additional related books is available.

Program: ELECTRONIC BOOKSHELF
Publisher: The Electronic Bookshelf, Inc.
Grade: 3-12
Hardware: Apple II Series and others
Abstract: The ELECTRONIC BOOKSHELF contains multiple choice quizzes to test students' comprehension of books and keeps a record of what books students have read and who has read them. Questions about books are randomly selected, thereby limiting the chances of two students getting the same questions on a book Points are earned based on the difficulty of the book. Fifty volumes (15-26 titles) are now available. Teachers and students can create additional data disks with questions related to books of their choosing. It is an excellent resource to stimulate students to read for pleasure.

Program: STORY STARTERS: SOCIAL STUDIES
Publisher: Pelican Publishers
Grade: 2-8
Hardware: Apple II Series
Price: $49.95
Abstract: Story Starters: Social Studies (SS.SS) is part of a Creative Writing Series designed to stimulate writing across the curriculum in grades 2-8. This versatile and user friendly text and graphic processor makes the process of writing fun while activating creativity. Full screen story processing and full screen graphic production are combined as students choose colorful backgrounds and clip art and manipulate these to create scenes for a variety of formats, namely, reports, posters, mini-books, big books, coloring books, comic books, and more. SS.SS can be expanded to include STORY STARTERS: SCIENCE, MONSTERS AND MAKE-BELIEVE, and DINOSAUR DAYS. These programs are interchangeable. Clip art and background are generated from the content of social studies textbooks and are used as backgrounds.

Program: THE SEQUENCER
Publisher: Teacher Support Software
Grade: 2-6
Hardware: Apple II Series
Price: $284.95.
Abstract: This program will help your students to summarize stories and to put the events in sequential order. It is a teacher/student tool which: a) encourages the retelling of stories, b) models sequential writing, c) offers three summarizing and sequence lessons, d) enables students to summarize stories, books, or units of study, and e) provides a management system. THE SEQUENCER supports reading and writing across the curriculum. Students can create open ended maps resulting from brainstorming. Prompts are provided to assist students in sequencing ideas and in recalling and organizing main events.

Program: THE SEMANTIC MAPPER
Publisher: Teacher Support Software
Grade: 3-6

Hardware: Apple II Series
Price: $254.95.
Abstract: The SEMANTIC MAPPER is a teacher/student tool which allows one to create maps, explore conceptual words in any content area, and organize thoughts for writing. It promotes higher order thinking skills, includes a management system, provides maps from basal stories and reinforces words from basal stories.

Program: THE LITERARY MAPPER
Publisher: Teacher Support Software
Grade: K-3, 4-6, Level 1 & 2
Hardware: Apple II Series
Price: $129.95 (K-3 or 4-6)
Abstract: After reading a book, students can explore character, setting, and plot. This program provides a database rich in language about these elements of story structure. Story maps are provided for six books at each level. These ready made ones may be used or one can create some for books being read.

Program: THINK AND WRITE
Publisher: William K. Bradford
Grade: 7-12
Hardware: Macintosh
Price: $45/$135
Abstract: THINK AND WRITE is a text processing program designed for writing research papers. It helps to organize the writing process through the use of the note card, which can be ordered, opened, and closed readily. Further, students can generate multiple note cards, can label each note card for easy reference, and can move material from one card to another. Note cards can be used to make an outline of their project. With a single command, note cards can be merged and the text integrated within a document. In printing, one has a choice of font style and size. The ELECTRONIC HANDBOOK (Technology Training Associates), a style/usage guide, can be used with this program.

Program: WRITE ON: PRIMARY COLLECTION
Publisher: Humanities software
Grade: K-4, Tutorial, utility
Hardware: Apple II Series, Mac, MS-DOS
Price: $375 Great Imagination, $675 Me and My World
Abstract: Write On: Primary Collection is a collection of 27 programs, each available for separate purchase. Using popular children's books and poems as motivators of student writing, this program is compatible with the word processors: Scholastic's PFS: WRITE, BANK STREET WRITER, and PRIMARY EDITOR PLUS. WRITE-ON is a literature-based approach to writing, in which students read books or poems and then write about what they have read, revise and edit their writing, and publish their ideas. "Great Wild Imaginings," for example, uses WHERE THE WILD THINGS ARE and other popular monster stories to stimulate students to write about their own monsters. Other choices on the menu are: real versus imaginary, similes, couplets, effective sentences and literary exaggeration. The collection is networkable and comes with a full-use license. WRITE ON ELEMENTARY COLLECTION and the WRITE ON INTERMEDIATE COLLECTION are available as well.

Program: PRIMARY EDITOR PLUS
Publisher: IBM
Grade: K-8
Hardware: PS/2, IBM Speech Adapter ($145)
Price: $131, $593 for school pack
Abstract: PRIMARY EDITOR PLUS is a flexible entry level word processor that includes a spelling checker; 40-80-column mode; eight-color selection; paragraph reflow; and mark, move and copy functions. Other features include a print editor which allows students to create/draw using the keyboard or mouse, a banner maker that prints signs in three different letter sizes, online instructional tutorials for the text and picture editor, text-to-speech voice capability, and networkability.

Conclusion

Recent research corroborates the effectiveness of computer-based instruction in integrated language arts instruction. When courseware is selected which is consistent with the goals of this instructional perspective, wholistic and multidimensional learning is facilitated.

The courseware reviewed by this author can be used in integrative teaching and learning. These programs are useful both across the curriculum and in conjunction with thematic, literature-based, or content area units of study. Computer-based applications effectively extend and enrich learning and at the same time make it enjoyable.

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Effectiveness of Computer-Assisted Learning for Reducing Test Anxiety

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Problem

The role of testing is becoming increasingly more pivotal, particularly with reference to entry into various professions (Center on Evaluation, Development, and Research, 1986). In the area of teaching, national reports have documented the greater reliance on the use of standardized tests for teacher certification (Holmes Group, 1986 and National Commission for Excellence in Teacher Education, 1985). As a result, a disproportionate number of minority preservice teachers fail to achieve the minimum passing score requirements thereby creating a nationwide shortage of minority teachers.

This study examined the effectiveness of computer-assisted test preparation instructions for enhancing education majors' test performance. It was argued that a comprehensive application of computer-assisted learning, within a responsive environment, is a major factor in reducing test anxiety and increasing test performance (Spielberger, 1972, Green, 1966, O'Neil & Richardson, 1980, McVey, 1989).

Methodology

The sample consisted of 131 education majors who voluntarily responded to a survey entitled: "Survey of Attitudes and Feelings About the Test Preparation Clinic

Table 1
Mean Text Anxiety and Achievement Motivation Scores by Academic Status

Abridged Items	Academic Status* 1 n=31 M	2 n=48 M	3 n=9 M	4 n=9 M
1. Feel at ease in TPC+	3	4	4	4
2. Motivated	4	4	4	3
3. Computers help	4	4	4	5
4. TPC helps	4	4	4	4
5. Studying is easy	3	3	4	4
6. Good progress	3	4	4	4
7. Study at home	2	3	3	3
8. Using computers	3	3	4	
9. Test is chance	3	3	1	2
10. Feel confused	2	2	2	2
11. Feel nervous	2	2	2	1
12. Computers frustrate	2	2	2	2
13. Feel competent	4	4	4	4
14. Feel panicky	2	2	2	2

* 1=Freshman 2=Sophomores 3=Junior 4=Senior
+TPC means Test Preparation Clinic

(TPC)". The survey measured students' perceptions of test anxiety and computer-assisted learning.

Results

Mean scores of students' responses are reported in Table 1. On all fourteen items, the majority of students responded positively, (M=3) and (M=4), to the TPC and to the use of computer-assisted learning. Where the Mean score is 2, students rarely felt such phenomena.

Discussion

The findings were in support of the use of computer-assisted instruction for reducing test anxiety and for improving students' self-perceptions of potential test performance. Also, the environmental quality in which computer-assisted learning was implemented seemed to be a major determinant of these students' use of computer-assisted test improvement.

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Computer Utilization in a College Reading Program

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Computer based instruction is the exception rather than the rule in college reading courses (Wepner, Feeley & Wilde, 1989). The Special Studies Reading Program (SSRP) at East Carolina University employs computers in computer assisted instruction, word processing, record keeping, and readability analyses. This description of a college reading program computer utilization, its challenges and future plans, may be helpful to others considering promoting computer usage in their programs.

Enhancing Teaching/Learning Effectiveness with Computer Assisted Instruction

The Special Studies Reading Program teaches reading/ study skills to first year students admitted as at-risk students. The pedagogical strategy includes a structured program with required hours of tutorial instruction in addition to regular classes. Teaching objectives include skills development in vocabulary, comprehension, rate and study skills. Individualized weekly lab assignments reinforce skills needed by students. In the last three years, commercial software packages have been purchased for use during the independent lab work.

Integrating computer-based instructional programs facilitates the accomplishment of several goals including: making students more active readers, increasing reading efficiency, achieving the course exit criteria, and overcoming negative motivation caused by past reading difficulties. The computer's capability for immediate feedback and its interactive novelty can improve learning motivation. (Hynd, 1986) Integrating computers as part of the instructional strategy assists our program in meeting its goals. A perceived added dividend is causing students and instructors to be more comfortable with modern technology.

Several studies indicate that computer assisted instruction contributes to student achievement through more academic learning time, more active student involvement and increased motivation (Day, Golden & Sweitzer, 1989; Tolman & Allred, 1984). Wepner, Feeley and Wilde (1989) cite Kulik and Kulik's meta-analysis of 101 computer based college level education studies. They conclude computer based education (CBE) has generally positive effects on student achievement and on the attitudes of college students toward instruction and toward the computer.

Of several commercial software packages purchased, a rate improvement program and a vocabulary development program have been used most frequently. Wepner et al. (1989) evaluated Speed Reader II, Davidson & Associates, used as a supplement to classroom instruction, to be as effective as traditional approaches for improving reading efficiency of college students (1989). Students using Word Attack have found it effective and enjoyable. Neither package has management capabilities, but both allow editing of word lists.

Three other software packages designed to improve reading comprehension have been used in the program on a trial basis. Each utilizes a student record management system to ease the teacher's record-keeping chores. The Reading Power Module, Education Development Laboratories, Inc. and Comprehension Power, Milliken Publishing Company, offer exercises in comprehension, vocabulary and rate. Only Learning Strategies, Science Research Associates, includes instructional tutorials with active feedback to the student. This interactive teaching/learning is its key strength. Integrated instruction with an appropriate amount of reinforcement, not merely practice exercises, is what our program needs in commercially prepared software.

Enhancing Software Capabilities

While software packages offer immediate benefits, many faculty will want to edit software or design their own. For most reading teachers using commercially prepared software is more time and cost effective than tooling up to develop individualized software. (Alexander, 1984) The SSRP designed a vocabulary development program that includes tutorials as well as practice exercises.

Augmenting reading and vocabulary instruction with computer based learning is saving valuable class time and appears to be an effective learning technique for the majority of students. Computer literacy and comfort with information technology are additional outcomes

Instructional Support Applications

Word Processing

A majority of SSRP instructors use the computers for word processing. Easy revision, speed and convenient storage are the major benefits offered. Weekly lesson plans, staff meeting agendas, quizzes, examinations, correspondence, and staff manuals are typical of the documents produced. These documents remain on disk to be referred to long after the last paper copy has been misplaced or misfiled. The computer has proven to be a formidable ally in information processing, storage and retrieval.

Record Keeping

Master lists of student names with test scores are kept on disk for easy reference. Placing this information on the computer has facilitated research being conducted in the program and has ensured safe storage. A potential for maintaining class records and grades exists but is not yet being tapped. Program budget, income and expenditure data can be recorded for later analysis.

Readability Analyses

The SSRP is currently using the Degrees of Reading Power Program (DRP), Touchstone Applied Science Associates, Inc. College textbooks are analyzed for readability levels. The analyses are calculated by MicRA-DRP, a software package in which text samples are entered and computations performed to assess readability levels. These analyses will furnish students with an objective assessment of how their reading abilities compare to the reading demands of texts.

Staff Training

The SSRP staff experienced typical difficulties implementing computer use in teaching. Wepner (1990) has noted that in order for computer use to be effective, teachers must be thoroughly knowledgeable about the software and the computers themselves. Lidtke (1981) lists possible reasons for resistance to computer use in education including a lack of understanding of the advantages and ways to use computers as well as computer anxiety. As computer technology and training become more standard in undergraduate education programs, computer anxiety at the graduate level should decrease.

Computer training and attitude change require time, a commodity in short supply for most instructors. However, as computer proficiency increases, computer use will make many instructor tasks simpler. After initial training, most instructors make time to learn word processing and instructional software. Fitting computer training time into an already full schedule is a constant challenge.

Students

Students must also be trained so they are familiar enough with both software and machines to establish confidence and comfortable work habits (Wepner, 1990). Students appear to offer less resistance to computer use because their computer tasks are relatively simple and repetitive and they are provided with more organized training and support than the instructors. Since reading on the computer is preferable to textbook reading, students are more positive about using it. Success in completing the program and in handling a computer providse powerful positive feedback.

Software Selection and Cost

Cost and selection difficulty are two factors that inhibit the purchase of computer software. Knowing that one can buy numerous books for the price of one software package is a mental barrier for some. Opportunities for previewing software are few and, unless it is seen through some type of network, consumers are often reluctant to buy blind. Many factors should be considered in selection including student population, instructional goals and teacher effectiveness. According to Hynd (1986) one should consider the software's ability to interface with existing hardware, its quality, its flexibility and its interactive capability.

Administrators

In order to expand use of computers, administrators must broaden their own computer knowledge. Many educational specialty journals are including regular computer information columns to share information about hardware and software packages dealing with their particular area. Administrators must find such sources of information appropriate to their programs.

More time must be devoted to formal training of instructors in all areas of computer use. Computer information overload must be avoided because it leads to frustration and increased anxiety. Time for planning and instructor support are important. (Lidtke, 1981) It is the program administrator's job to see that the instructors get sufficient feedback and application time to become comfortable with software and hardware.

To develop computer assisted and managed instruction further the SSRP will evaluate its use and plan how best to expand. Expanded use will also require a more structured approach to evaluation of software programs. Alternative statistical tests will be analyzed to assess the effectiveness of the comprehension and the rate programs currently in use. Evaluation methodology needs to be integrated as an on-going program feature.

Computer integration is a viable diagnostic, pedagogical and managerial methodology for the Special Studies Reading Program. Selling this approach to instructors and students is an important leadership task. Mounting national evidence supports this assertion.

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Curricular Integration for Computer Literacy Teachers

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"Curricular integration of technology" will be defined as any use of technology (such as computers, videodiscs, etc.) which directly supports the teaching/learning process for a specific curriculum area. It may be used to assess and/or remediate prerequisite skills and understandings, to support direct instruction, or to extend/challenge understanding of concepts which are part of the subject curriculum.

There are many specific ways that computer literacy teachers can utilize tool and content-specific software, as well as programming activities, to directly support instruction in the computer literacy curriculum itself. These uses may relate to computer applications, programming, computer terminology, computer history, and/or societal issues of technology.

Students can develop word processing skills by creating and editing essays, reports, or letters on computer history, computer careers, and societal issues of computing topics. Students can also practice predicting and/or debugging programming code in a word processing environment, without the built-in feedback provided by a language processor (compiler or interpreter).

Students can create and search databases of programming language keywords, terminology, or resources (software, hardware, print materials, and/or human expertise). Partially completed databases can be completed by students as an assessment activity.

Students can use graphics packages to flowchart programming assignments, create "responsible computing" posters, or present humorous visuals of such computing terms as "cold boot" or "split screen." General-purpose teacher utilities such as crossword puzzle makers and word matchers can be used with computer literacy terminology. Consider using a program that focuses on sequencing to emphasize this important concept in the study of programming.

When students carefully enter a lengthy program from a printed source, and work to correct their errors to produce a working program, the topic of computer piracy may take on a new, more personal meaning. Public domain versions of many types of tool programs are often available with their source code. Students can begin to appreciate the complexity of "more powerful" programs of the same type by studying these programs.

Advantages of using computer literacy curriculum topics as targets for practicing software use skills seem obvious. Students can keep their minds focused on the subject of computer literacy rather than mentally shifting to social studies to work on a database about the United States, or language arts to write a poem, letter, or story. By repeated exposure to the use of software tools, students have many opportunities to become comfortable with that software. They may begin to see that a given piece of flexible software is not generally limited to any single subject matter. Although some content-specific software can be used in flexible ways, the ease with which tool software and programming languages can be used for different subjects serves to underscore the power of those programs.

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Robotics in Teacher Education

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In teacher education programs, robots, like computers, can be studied for what they are, how they work, what they can do, their impact on society, and how they can be used as instructional aids. A robot is defined here as a mobile device that can perform work, even a simple task, and possibly do work usually considered the domain of human workers. Robotics, the study of robots, is limited in this paper to include robot literacy and robot-assisted instruction. The paper is a consideration of certain aspects of robotics for inclusion in the teacher education curriculum. In particular, robot literacy, robot-assisted instruction, integration of robotics into the teacher education curriculum, and teaching a robotics unit in teacher education will be considered. An outline of a sample unit on robotics and a selection of resource materials is also included.

Robot Literacy

Robot literacy is the study of robots; what they are, how they are used, present and future impact on society, and other information about robots in general. It is expected that robot literacy will grow in importance as a subject of study as the use of robots gains a larger place in our society.

Robots are being used increasingly throughout the world in a wide range of applications. They are used in such areas as agriculture, commercial services, food services, health care and medicine, laboratory work, manufacturing, the military, police work, rehabilitation, sports, surveillance, underwater and space work and exploration, the home, and as aids to the handicapped. Robots are especially well adapted for jobs that are boring, repetitious, dangerous, or even physically impossible for humans. They are being used side by side with human workers in many occupations, and the social and economic impact of these new co-workers is already being addressed (Albus, 1984; Ayres, 1983; Frude, 1983; Simon, 1983).

Many schools at all grade levels in the United States and other countries are including robot literacy in their curricula. (See, for example, Blaesi and Maness, 1984; Decker and Krajewski, 1986; Sharon, Harstein, and Fischer, 1987). Robot literacy is being taught as a full course of study (for example, Gray, 1986; Heckard, 1986), as a unit of study (for example, Greene and Smith, 1986), and in special programs varying in length from a few hours, or one day, to a week or more. Some high schools also provide industrial robotics courses (for example, Gromacki and Hannemann, 1989), but these will not be considered here because they are usually in high school industrial education programs.

Robot-Assisted Instruction

Robot-assisted instruction includes any use of a robot as an aid to instruction. The robot may be student-made using a wide variety of materials, or a commercially available robot. Robots are highly motivating in the classroom, and have been used in many instructional roles at all grade levels. (See Bitter & Gore, 1985-1986; Ehrlich, 1988; Keller, 1983; Walsh, 1986.)

Robots can assist in the educational process in a variety of ways. For example, they can perform simulation activities related to the use of robots; illustrate computer science, electronics, and mathematics principles; serve as an introduction to technology; and act as catalysts for discussions, writing projects, research, and experiments. In addition to these uses, imaginative teachers have used educational robots and robot building kits to accomplish a wide range of instructional objectives. (See Pantelidis, 1991, for references to many uses of robots in instruction.)

Integration into the Teacher Education Curriculum

As with the introduction of anything into teacher education, the introduction of robotics must be thoroughly integrated if it is to be successful. This integration is a multi-layered problem. It must include robot literacy as well as robot-assisted instruction, tailored to fit the course or courses into which they are placed. A separate course on robotics in education is easier to implement, but more impact will be realized if the material is integrated into existing courses in the teacher education curriculum.

Robotics can be integrated into the teacher education curriculum in courses covering all grade levels and almost all subject specializations. Computer literacy, methodology, and technology courses all are courses where a unit on robotics could be included. Such specializations as business, computer science, industrial technology, language arts (e.g., fiction involving robots), mathematics, science, school librarianship, social studies (e.g., impact on society), special education, vocational education, and humanities (especially film and theater, but also art and music) are all areas that can include subject-specific robotics units.

Teaching a Robotics Unit in Teacher Education

A unit on robotics, wherever it is taught in the curriculum, should include both informative material and demonstrations of different types of robots.

Educationally useful robots include turtle robots, mobile robots, and robotic arms. Robot building kits are also available and are useful learning tools. (See Pantelidis, 1991, for lists of educationally useful robots and suppliers of robot parts.)

When presenting a robotics unit, sufficient hands-on time should be allowed to acquaint the student with the features of the available robots. The use of demonstration robots and robot building kits will aid the student in understanding what robots are and what they can do.

Robotics Unit Content

Teacher education students should be given general material on robots, material on using robots in the classroom, and material specific to subject specializations. A unit on robotics might include the following outline. A list of selected resources follows the outline.

I. General Information (Robot Literacy)
   1. Definition
   2. Background
      a. what a robot is
      b. types
      c. history
      d. robot anatomy, movement, control, and capabilities
   3. Applications
      a. why robots are used
      b. specific uses
   4. Importance
      a. implications for society, education, and human safety
      b. economic and workplace impacts
      c. future uses

II. Robot Literacy in the Curriculum
   1. why to include robot literacy in the curriculum
   2. where robot literacy fits into the curriculum
   3. how to integrate a unit on robot literacy into subject areas and/or specific grade levels

III. Teaching Robot Literacy
   1. what to teach about robots (according to grade level and/or specialization)
   2. how to teach about robots
   3. support material available

IV. Using Robots in Instruction (Robot-Assisted Instruction)
   1. Definition
   2. Background
      a. types of educationally useful robots
      b. history of use
      c. research on use
   3. Classroom Applications
      a. general reasons to use robots
      b. when to use robots
      c. ways to use robots
   4. nonfiction and fiction, print and nonprint materials available for specific subject areas and/or grade levels

Selected Resource Materials to Accompany Robotics Unit

Many print and nonprint materials are available as resources for a unit on robotics. Nonprint materials include such formats as computer programs, videorecordings, films, slides, and sound recording. Following is a sample of helpful printed materials.

Asimov, I., & Frankel, K. A. (1985). *Robots: Machines in man's image.* New York: Harmony Books. (General introduction.)

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Moravec, H. (1988). *Mind children: The future of robot and human intelligence.* Cambridge, MA: Harvard University Press. (Discusses present and future evolution of human equivalence in robots and computers.)

Pantelidis, V. S. (1991). *Robotics in education: An information guide.* Metuchen, NJ: Scarecrow Press. (Provides nearly 1,600 annotated references to print and nonprint materials on robots, designed for kindergarten through 12th grade levels.)

Radlauer, R., Radlauer, E., Mather, J., & Mather, B. (1985). *Robot tech talk.* Chicago: Childrens Press. (Juvenile level dictionary.)

Westcott, S., & Mager, R. (Eds.). (1985). *Robots: A teacher's guide to resources and activities.* Pittsburgh, PA: Buhl Science Center. (Provides ideas and activities.)

Evaluation Research Needed

As any reading of the literature on robotics in education quickly demonstrates, nearly everything published has been directed toward demonstration projects. Very little research has been done to consider the value of robotics in the school's education curriculum. In the next decade, if robotics is to be fully accepted in education, there must be research undertaken to examine the effects of robot-assisted and robot literacy instruction, the place of robotics in the curriculum, and how to integrate robotics into education.

Conclusion

As a part of the growing field of robotics, schools are including robot literacy in their curricula. Robot-assisted instruction is being used at all grade levels and in many different subject areas. Thus, it is important that teacher education programs consider adding a unit on robotics as part of their preparation curriculum.

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Classroom Experience in Preservice Computer Education

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Background

The School of Education's preservice teacher education program at the University of Colorado at Colorado Springs is typical of many fifth year programs throughout the nation. Students participate in a range of instructional activities that includes classes in subject area methodology and classroom management, and field experiences that include observations and student teaching. Each student is required to take a class in educational computing, and almost all students choose to schedule this class prior to the teacher preparation program year.

Students are not formally required to include computer use during their student teaching semester, although many of the cooperating teachers to whom they are assigned are themselves computer users and encourage students to make use of computers in their teaching. Conversely, some student teachers never observe computer use nor do they incorporate any computer applications in their initial teaching experiences.

Although our introductory computer education course includes a substantial experiential component, the actual experience of observing and working with children as they use computers is not formally included for all preservice students.

The Problem

Students who elect to take their computer education requirement prior to their year of preservice teacher education usually have full daytime schedules that include classes, jobs, and family responsibilities. Three of four classes meet after 4:30 p.m. For this reason, we are unable to require classroom visitations of all students because their schedule may not allow them to visit classrooms between 8 a.m. and 3:00 p.m. One of our classes meets in the early afternoon.

The ideal situation would have students experiencing computer use with children early in their observations and in their student teaching. However, supervisors of student teachers could not realistically expect most students to move past the initial stages of concern with classroom management issues, particularly in a complex computer-rich environment, in the short semester of student teaching.

Our goal is to provide initial exposure to the computer classroom so that students gain confidence with management issues. Thus, any experience with computers during student teaching could more reasonably address concerns such as lesson planning, curricular goals, and student outcomes.

The Experiment

Students in the daytime section of the introductory computer education class were given the option of substituting a classroom visitation experience for one of the course assignments for a total of 30% of the course grade. They were required to visit the school at least 10 times and keep a diary of their weekly experience. Some students elected to visit neighborhood schools and others asked for an introduction to a local elementary school that had agreed to participate in this program. Ten of the 23 students enrolled in the daytime class chose to participate in the classroom visitation program.

Participants were instructed to meet regularly with their cooperating teacher to discuss planning and procedures. In many cases, the cooperating teacher had limited experience with computers and they welcomed the students' participation since students were learning about a wide variety of applications in their university class and were able to assist with planning. They also discussed student progress, problems with computer operation and use, and individual needs. Participants were aware, from discussions in the university classroom, that this dialogue was an important factor in their school experience.

Participants were asked to keep a weekly diary of their school visits. The diary was to include both reflections on their observations of students and their participation, as well as their discussions with teachers. The diary had the dual function of a report on activities and an opportunity to reflect on issues, benefits, drawbacks, and processes related to computer use with children.

The participants' function in the classroom was to assist the teacher and students with questions and procedures. These activities included booting disks, copying disks, correcting student posture, giving hints and instructions, asking challenging questions, helping students to focus on a task, working with individual students or small groups, recording scores or performance, providing feedback, and encouraging exploration.

A survey of participants was conducted early in the semester to determine previous experience with computers and students' perceived comfort level with computer use. Only four of the ten participants rated themselves quite comfortable with computers. Two participants rated their confidence at the lower end of the scale.

A follow-up survey was conducted to rate such factors as course relevance, confidence with computer use, and confidence with teaching with computers. Cooperating teachers were also asked to comment on their experience in working with the university participants.

The Results

The purpose of this informal study was to compare the effects of classroom visits with the effects of participating in the introductory class without the benefit of classroom visits. Students' level of confidence with computer use was measured on a 6-point Likert scale. Prior to the class, students in the experimental group (n=10) rated their level of confidence as averaging 3.1. Students in the control group (n=13) averaged 4.2 in confidence level. This indicates a substantially lower level of confidence in computer use. Responses to the statement, "I have confidence in my ability to use computers," were rated as follows: 1 = strongly agree; 2 = mostly agree; 3 = agree somewhat; 4 = disagree somewhat; 5 = mostly disagree; and 6 = strongly disagree.

At the end of the semester course in computer education, the experimental group averaged 1.5 in level of confidence, with a slightly lower level of confidence in the control group with a 1.8 average rating. The average change in confidence level was 1.6 for the experimental group and 2.4 for the control group.

The relevance of the course relative to the use of computers and other technologies in teaching was rated as an average of 1.2 by the control group and 1.3 by the experimental group.

Students were then asked to rate their confidence level in the use of microcomputers in the classroom. Students in the experimental group averaged 1.5 in their rating. Individual scores ranged from 1 to 3. This indicates that all respondents are at least somewhat prepared to use computers in instruction. For the control group, the average rating was 2. Scores in the control group ranged from 1 to 5.

Although the differences in scores were not statistically significant, students who had had the opportunity to visit classrooms were generally more confident in their ability to teach with computers. Six of ten respondents in the experimental group rated their confidence level as highest (with a score of 1), whereas only 4 of the 13 students in the control group did so.

Students' comments and diaries revealed important anecdotal information about the experiment. Participant typically entered the classroom with comments about the benefits of their experience, and frequently contributed examples and anecdotes about their classroom observations that were relevant to the topic of the day. For example, one student related her experience in working with children who were using word processing without previous keyboarding experience. She convinced her fellow students that the difference in keyboarding speed was dramatic when students at the third grade level were given some keyboarding practice.

Diary entries described a wide range of reactions to the classroom experience. The majority of comments were descriptive, indicating the procedures followed and the activities in which students participated. Most students also included comments about the value of their participation. For example, one student noted, "... overall I feel a lot more relaxed around computers. They (don't) intimidate me any more." Some comments also revealed concerns about student performance, an indication that some students had moved beyond an initial stage of concern about classroom management. An example of such a comment was, "In just a matter of six weeks, I have documented the progress of this first grade class. Granted, each group that came into the lab was different homogeneously. Yet, each group persevered diligently at their own pace—progressing along the way." Additional student comments from diaries and survey forms are listed in Table 1.

Finally, many students ended their diary entries with enthusiastic comments about their participation and at least half indicated that they would continue the visits after the end of the semester if their schedules allowed.

Nine of the ten cooperating teachers responded to a follow up survey. They were asked to comment on the benefits and drawback of the program. All of the cooperating teachers indicated that the main benefit to them of having a student in the computer lab was the opportunity to work with individual students without worrying that the rest of the class was neglected. They had more time to spend on individual interaction. Seven of the nine cooperating teachers responding found no drawbacks to the program, and two commented that they would have preferred to have only one university student with them in the lab. In the latter cases, two students were paired with one teacher and a parent volunteer also assisted in the lab. A sample of representative comments from the participating teachers is given in Table 2.

Conclusions

The implementation of a program of classroom visits continues to be difficult since it cannot benefit students who take the introductory course in the summer or who enroll in the evening classes because of a full daytime schedule. The benefits to participating students were encouraging, though, and some alternatives will have to be explored to provide this experience for a larger number

- (early diary entry) This is going to be fun!
- He (cooperating teacher) was a lot of fun to work with.
- It is so great to see these (fourth grade) kids moving sentences, deleting characters & some even typing!
- They pick it up so easy—not like me!
- It surprised me how relevant the questions were and how much he picked up in such a short time.
- . . . before I could explain, she just started pushing buttons—any and all buttons; Twice I had to put her hands in her lap and say, "Please just listen a minute and I will explain."
- Mr. B. told me that he thought it was really good for them to work one on one with me at the computer. . . this made me feel **great!**
- I kind of like this hectic stuff—it makes things exciting.
- One of the students was very eager to give up her computer. I think she was frustrated.
- I felt as though I had contributed and that was nice.
- . . . the girls made me feel liked and important to them.
- I got the disks out and booted them. By the time the teacher and kids arrived in the lab, everything was ready to go. I was proud of myself.
- The students keep calling me "computer lady."
- I've learned more respect for teachers as people and the fact that they never stop learning new things as long as they're with kids.
- I can't imagine any teacher not knowing something about computers in the future....
- I really gained confidence in learning to work with computers. I would be thrilled if more academic studies concentrated on practical education.
- This project made me learn to use the software. I also learned a lot about classroom management and how computers could be used for other subject areas.
- There's nothing like experience to solidify in one's mind the otherwise theoretical information given in the classroom.
- I benefited from watching how the teacher interacted with her students . . . she included me in absolutely everything

Table 1
Students' Comments on Classroom Visitations (from diaries and survey forms)
Notes in parentheses are researcher's explanations.

- When students ran into problems, there was another person to help them. It was less frustrating to me and the students.
- I have been able to plan lessons that require more than one adult in the lab.
- I really enjoyed this experience. It helped keep me on my toes and question my methods. Send me more!
- It would not have been possible for me alone to have given the kids such extended one-to-one time.
- No drawbacks—can we keep her for all year?
- We were able to count on her computer knowledge and her wonderful ability to relate to these students on a regular basis.

Table 2
Participating Teachers' Comments (from survey forms)

of students.

One alternative is a separate requirement that students can fulfill prior to or after taking the course. We have already revised our course to include a separate, compulsory lab class that is entirely experiential ("hands-on"). The visitation component might be offered as a practicum and would have to include opportunities for scheduling visits outside of regular hours, such as adult classes, special summer programs, or after-school activities for children in a computer lab. An example of such an opportunity is the School of Education's Super Saturday program of courses for gifted children.

We can perhaps expect that, eventually, student teaching experiences will include a requirement that students be paired with technology-using teachers and that such use will also be required of the student teacher. Until such time, every effort must be made to include some experience that involves interaction with children as they use computers. Another alternative is to include this experience in the regular observations that students are required to complete prior to student teaching. Of course, this latter alternative presents a substantial management problem, particularly in regard to the assessment of the participant's performance. Again, a diary of experiences would provide the necessary information.

We plan to maintain our efforts at the University of Colorado at Colorado Springs to ensure that each student eventually has the opportunity for experiencing the positive effects of computer use by children, as well as gaining enough expertise in the computer environment to gain a realistic perspective of the complexity and planning requirements of such activities.

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INSERVICE & GRADUATE EDUCATION

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Much of the literature on technology uses in education addresses innovative solutions to old problems. Clearly, rapid advances in technology have brought new challenges that must also be addressed, perhaps not as problems, but as opportunities to reevaluate old paradigms and reexamine assumptions about education. A few years ago, my favorite quote by an unknown author said something like this: "The question is not what technology will do for education, but what, given technology, *is* the educational enterprise?"

The authors in this section address new questions that raise issues about adult learning. Wright describes the "Power Context" of education, including resistance to change, planning for change, and the management of change. Although modern technologies have the potential to change the way school administrators do business, none of these changes can be expected unless they are implemented deliberately. As Alan Kay puts it, "We cannot assume nor expect that computers will change education, just because they could."

Harris writes a descriptive article on adults' experience with new learning. In the process of reflecting on their own learning, the adults in the experiment learned about their own learning process. Lifelong learning is an important goal for our students, and we are seeing excellent dialogue about changes in curriculum that prepare children for becoming lifelong learners in their adult years. Harris addresses the more immediate need to begin the lifelong learning process with practicing teachers.

Carey and Carey also write about the continuing education of adults, bringing the broad context of education and training within the purview of a school of education that traditionally prepares teachers. Clearly, the definition of "teacher" extends beyond the walls of the traditional K-12 school, and the institutions of higher education that we have in place today. The workplace itself offers a reasonable context for learning, and the notion that schooling is only the beginning of a lifetime of learning fits well with the corporate computer-based training model that is proposed here. Teacher preparation institutions can be the ideal source of continuity from the classroom to the workplace.

Andragogical Models

The education of adults is not the only common thread in the three articles in this section. A model of education that assumes that the student is a capable, reflective, and responsible decision maker is needed so that adults are empowered to take charge of their learning and select educational experiences that meet their needs. A further benefit of this type of andragogical (as opposed to pedagogical) model is that it also works well with many children. And we have seen that such basic changes will not occur in the classroom unless educators have experienced these changes as learners themselves.

The broadest questions about the use and role of technology in teacher education are the focus of the STATE organization. Specifically, we must ask how technology use, both as the means and the curricular outcome, can be integrated into preservice teacher education programs. A second specific area of investigation is the continuing education of practicing educators at all levels. The three articles in this section offer considerable food for thought about models for assessing needs, designing instruction, and involving adults in the change process.

University Programs in Corporate Computer-Based Training

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Introduction

The traditional view of education as formal schooling within the confines of the classroom, including the college or university lecture hall, has been rapidly dissolving since the influx of educational technologies. Formats such as distance education, corporate training sites, self-instruction with computer-based tutorials, and televised instruction have gained much attention in the past decade. Educators involved in teacher training must also expand their view of education and realize that the mission of schools and colleges of education must accommodate this broader definition of education. Not only has the context of education evolved away from the formal classroom, but the view that education covers a limited span of a person's life is no longer valid. The work world that graduates of our institutions enter makes great demands on their ability to learn, adapt, grow, and apply their learning skills.

There was a time when a doctoral degree was also titled "the terminal degree." Clearly, in an information revolution and a technological evolution, no amount of education can be considered terminal. No single discipline is static; every educated person is responsible for the updating of both the information base and the skills of his profession.

The Challenge

The question remains, "How can a university department or college involved in teacher preparation expand its view and redefine its mission to include lifelong learning?" Clearly, divisions of community and continuing education have traditionally taken on the mission of educating and retraining adults. Some of the retraining needs are handled within the corporate or industrial site. The need is clearly broader than one of retraining. A virtual army of educators will be needed to provide all of these services, both on site and away from the workplace. The preparation of "teachers," then, must be expanded to include the trainers who work outside of the traditional institutional framework.

This paper describes such a program, embedded within an institution's educational computing and technology program. This program's mission is to provide modern, relevant instruction on the design of instruction for the corporate client.

The Need to be Served in the Corporate Community

In the Fall of 1988, the University of Colorado at Colorado Springs' Educational Computing and Technology faculty were approached by a local consultant to discuss the possibility of establishing a program that would serve the needs of corporate trainers who design instruction for adult learners.

The problem was clearly defined, and the needs were distinct. In the Colorado Springs area, many corporations were under contract to the military and the government. Their task was to utilize authoring systems to design computer-based training, with some contractors responsible for the design of instruction in other formats such as stand-up instructional support, paper-based instruction modules, and videodisc systems.

A problem existed in the designers' backgrounds: most had substantial backgrounds in such areas as engineering, applied science, computer science, military science, and management. The few employees who had any instructional design background were typically former teachers. Even with the former teachers, knowledge of instructional design was minimal, as the experience base tended to include mostly curriculum development and stand-up instruction preparation (the lesson plan).

The need, then, was to provide a substantial basis for instructional design, and some experience with the design process. Although the designers and authors had knowledge of the subject area and had access to subject matter experts (SME's), they did not possess any knowledge of learning theory, adult learning styles, and research on teaching and learning. Much of the intuitive design implemented by these authors tended to be centered on information delivery, usually linear, and restricted to textual formats.

The UCCS School of Education was reasonably well prepared to meet these coursework needs. Many teacher preparation programs already offer learning theory and educational psychology courses. At UCCS, we also offered an Instructional Design course, and we were prepared to expand our educational technology electives to include some necessary design courses.

We also had to consider scheduling needs of potential graduate students in this corporate program. The students came from a wide variety of backgrounds and had schedules that rarely allowed them to come to our campus before :30 p.m. Many already held a master's degree in their area of specialty. We had to be prepared to offer a program that was highly flexible to meet emerging corporate needs, but also fairly structured so that students could plan their own schedules around their work hours, travels, and vacations.

The Role of the Academic Community

Our first task at the School of Education was to decide whether we could and would respond to the community need. Our physical resources were minimal for any leading edge high tech offerings, but we felt that we could accommodate the coursework needs. We surveyed potential part-time faculty in the area, and found a good number of specialists in the corporate and military community who could provide the needed instruction and also possessed the doctorate that the School of Education requires for graduate-level instruction. Best of all, we found enthusiasm and support from some corporations that were prepared to subsidize their employees' studies in our program.

The second immediate nee s to move with considerable haste to implemen he program. Innovation in higher education moves with deliberate slowness, and we needed to show some willingness to accommodate the corporate pace. Our solution to this problem was to expand an existing program rather than establishing a new program that would take years to move through the various levels of program approval.

The existing graduate program in educational technology drew its students from the ranks of practicing teachers. The typical candidate held a degree, some years of teaching experience, and at least one year of teacher training coursework. The corporate candidates could be expected to hold a college degree, but no coursework in education or psychology. We also had to recognize that many of these corporate candidates would come to our program with a number of years of experience in instructional design and courseware authoring, without any formal or informal instruction in this area.

Program Overview

The corporate track within our educational technology program was built around several existing courses. The outcome of the program was a Master's degree in Curriculum and Instruction. Therefore, every participant must include the two core courses of this program: Social Foundations of Education and a course in Research and Statistics.

The five courses central to the corporate emphasis of our program are:

- Computer-Based Training and Emerging Technologies
- Educational Applications of Learning Theory
- two courses in Instructional Systems Design, and
- Evaluation of Computer-Based Training and Education programs.

In addition to the seven courses that make up the core requirements, participants must select three elective courses and complete a project that applies Instructional Systems Design theory. An advantage of offering elective courses is that they usually accommodate our traditional population of graduate students who are classroom teachers. Topics might include Videodisc Design, Multimedia Applications, Management and Administration of Training, or Issues and Trends in Educational Computing and Technology.

Several of our courses follow a seminar format in which students are active participants rather than passive observers. Students are responsible for the selection of some of the content, its delivery, and its evaluation. One of our goals is to model the andragogical approach that we emphasize in our Learning Theory course.

Our course designs also include a number of field trips to local sites in which modern computer-based and technology-based educational media are implemented. In the past year, students have visited the U.S. Air Force Academy's foreign language laboratory in which classroom instruction is supplemented by interactive videodisc instruction in a number of languages. They have visited corporate sites, a film studio, and sites where contract work is done for government and military clients. Guest speakers have visited the classes, and a number of students selected speakers and brought in videotaped segments during their seminar presentations. All of these resources are vital to a small program with few technological resources. We count heavily on our corporate neighbors and their willingness to welcome us to view their facilities.

The sequencing of courses has been difficult since we have decided to offer access to the program at the beginning of each semester. The two core education classes are offered every semester, including summer. Other courses in the corporate program are offered on a two-year cycle, with at least two offerings for each semester. Students who miss the beginning of the cycle of core courses may choose some electives for their program of study. Independent study is also encouraged, although a maximum of six credit hours of independent study credit is imposed.

As preparations for the program fell into place, an experienced colleague suggested that some thought be given to the needs of students who already possess a master's degree. He helped us to realize that a graduate degree would not meet the needs of all clients, and that some may seek coursework in instructional design, but they might not be prepared to work through our admissions process. It was decided to package six courses into a Certificate Program to accommodate these clients.

This turned out to be highly beneficial to all concerned. Some local corporate sites were interested in offering the Certificate courses on site, and this was arranged easily through our Division of Continuing Education. We felt that we could offer a customized program to these corporate students, with flexible hours, both during their work time and outside their regular hours. Students in the Certificate Program have a great advantage in that the employer pays tuition for 18 credit hours of study, and they are more than halfway through our graduate program if they decide to pursue the Master's Degree.

Program Review

After the first year of implementation, the program design was reviewed. The first substantial change made was to resequence the courses. The Computer-Based Training and Emerging Technologies had originally been designed to occur later in the course sequence. It was repositioned to be the introductory course. The Applications of Learning Theory class was also scheduled to occur before the beginning of the Instructional Design sequence.

Program requirements were adjusted because of our inability to offer courses on a yearly basis. We also needed to allow more than one point of entry per year. After the redesign of the program, we retained only seven required courses and the project rather than prescribing eleven classes. Instead, students meet with their advisor to select three electives. A major factor in the selection of electives is the student's own schedule, the desired semester course load, whether a summer course is an option, and how often the elective is offered.

The program does not yet have a large enough enrollment to accommodate full-time students, but we have managed to meet the needs of some students by allowing them to join courses at the corporate sites. Although this solves an immediate problem, it is not a long-term option for most students.

One of the goals for the near future is to acquire appropriate equipment and software to provide multimedia stations for development purposes. We feel that our students are capable of sophisticated production, and we need to set up environments in which they can apply new skills. Until now, experience with authoring and development has been arranged in off-site independent study situations.

Another goal for the future is the establishment of corporate internships for the students. Several students need a stepping stone into the workplace, as they have no previous experience, or they are currently unemployed. The advantages of working with the corporate community are numerous, including stronger ties, possible direct support of the program, and access to sites for field trips.

Afterword

The success of the corporate training program thus far may be attributable to many things, some of them intangible. A key factor was response time. Students and corporate clients would not have waited out the typical program planning years. Another is a subtle shift in the view of the student as learner to that of client. Finally, we continue to work on communicating the rationale and philosophy of the program to students so that the coursework pieces fit into the larger framework of the program.

Although we had not envisioned our role in the corporate world when we initially pursued studies in educational technology, the application of these technologies and theories beyond the walls of the traditional classroom has given us a broader and richer view of both instructional technologies and of education itself.

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Technology in the Power Context of Education: Implications for the Education of School Administrators

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Defining Technology's Impact on School Administrators

Technology is rapidly altering the ways schools operate. Brand, in *The Media Lab* (1987), states that our ability to digitize information is as important as the invention of the movable type printing press. DeBuse (1988) identifies six key developments accelerating change and altering power relationships: 1) Powerful and portable computers available everywhere; 2) Graphic interfaces and simple pointing devices (the mouse); 3) Optical storage devices; 4) Hypermedia (or hypertext) to organize and provide multiple level access to very large databases; 5) Artificial intelligence using expert systems to assist people finding what they want; and 6) Authoring systems that permit the publication and use of hypermedia materials and other interactive publications. He sees these technologies creating a monumental shift in the ways information is used.

School-based technological applications (computers, workstations, local area networks, electronic mail) can increase efficiency in information management and communication. Computers allow the administrator to find, process, and disseminate information more efficiently. When one workstation is tied to other workstations through a local area network, the information management and communication process becomes even more efficient. Text and numeric data that once had to be assembled by hand can be accessed using integrated word processing programs. Analysis of operating efficiency of the local school can be done using spreadsheet programs. Information from remote sites can be acquired through online database services. Higher quality printed and graphics materials can be produced. Properly managed, these resources allow the school administrator to not only do what was done before, but to do things that were not possible before.

The question is not, "Will we use technologies?" but rather, "How will we use these technologies to have the power to meet our school's goals and objectives?" The systems are upon us. The question remains, can school administrators be empowered? Or, will these new systems simply create more demands on administrators, teachers and students—thereby weakening all personnel and the entire system? Some obstacles to effective utilization come from incompatible software and equipment, ignorance of possible positive effects of technology, or lack of experience with software applications for school administrative functions. However, the major obstacles to effective school-based systems are people-related, not computer-related. This paper considers those people-related obstacles.

Personnel Resistance to Revolutionary Change

Scientific American (1989, p. w1) introduces a special section on "the workstation revolution" with these words:

Every year new stories about the emergence of faster, more functional, and, in defiance of generations of economists, cheaper computers appear. And every year come new claims that we are in the midst of a revolution. We are in the midst of a revolution. It is not simply because computers are getting smaller and cheaper. The word revolution implies something more dramatic. The computer revolution is about the fundamental change occurring in the relationship between human beings and computers. The way we work with computers is changing dramatically. In this revolution, the workstation has become the most visible agent of change.

Peters (1988, p.637) issues the following warning:

...implementation of the new integrated information technology-based systems is much more difficult than anyone dreamed. For one thing, it turns out that the installation of such systems is not primarily a matter of technology. It is a matter of organization. *Every* power relationship, inside and outside the firm, is affected by the installation of the new information technology systems.

For administrators, the central issue is helping people *manage change*. Technologies introduce new methods, relationships and work patterns. Preservice programs for school administrators need to introduce students to change processes in organizations, obstacles to change, and methods for assisting staff through the change process. If resistance to change is overcome, people are willing to learn how to use these technologies. Some will resist change as evil or unusual and put a great deal of effort into keeping things the same. The pace of change may cause people to feel that technology is taking precedence over the people. Figure 1 illustrates some individual responses to change as the individual evaluates change.

Individuals' evaluation of change is dependent on (1) information known about the change, (2) the extent of participation in decision making processes, (3) how much the administrator is trusted, and (4) past experience with change. Thus, resistance to change is dependent on the climate of the organization created by the administration. Possible positive and negative organizational effects of technology are shown in figure 2.

A change is proposed → Individuals evaluate impact on themselves → Individuals respond

The following evaluations and responses are possible:

Evaluation	Response
Destructive	Resist openly
Threatening	Resist covertly
Uncertain	Tolerate
Positive	Support, participate

Andriole (1985, p .290)

Figure 1.

Steps in Helping Staff Through the Change Process

If systems work, all of the school personnel with personal computers on their desks must be using the system to communicate and to improve the work process. No school can afford to support three information work process systems: the way we did it, the way we do it with computers, and the way we are supposed to do it. The administrator's time will be spent helping and encouraging staff to move their work onto the computer workstation or the local area network environment. Specific steps in the change management process are suggested below.

Step 1. Show Concern for the Work of the Staff

The school administrator can show a knowledge of the jobs people do and a concern for that work. Often the question is, "Does the boss know and care about what I do?" As Hutchins (1947, p.138) said long ago:

The administrator should never do anything he does not have to do, because the things he will have to do are so numerous that he can not possibly have time to do them ... He should have the largest number of good associates he can find.

"Good associates" at all levels of the school are essential to the school administrator. Empowering others means that the power of technology is directed toward good ends. When everyone's role and responsibilities are clear, the staff can function more effectively. The school administrator needs to be frank about his/her motives in suggesting the change—what are the "rewards" that this change will bring about and why are they important to the school?

The basic principle should be a balance between productivity and worker well-being. The worker's well-being can be enhanced when the job design allows for challenges to be built into work tasks. Work that is too simple breeds boredom and often hostility. When workers can learn new skills and assume new responsibilities, they have a sense of contributing to the organization as a whole; they are empowered.

Brod (1984, p.180) suggests several dimensions of present and future work design that need to be taken into account:

- knowledge: Are workers' skills being fully used in their present jobs? Is their work sufficiently challenging? Do they want more opportunity to learn new things?

AFFECTED AREA	POSITIVE EFFECTS	NEGATIVE EFFECTS
Work quality	• wide data access, fewer lost items • wider participation in creating & reviewing data	• indeterminate or mediocre data quality • reduced independence and initiative
Productivity	• more work handled by more powerful equipment	• greater resources used for inconsequential work
Employee changes	• improved skills, more challenge • reduced status distinctions	• fewer jobs for marginal performers • less personal interaction • not enough status distinction
Decision making effectiveness	• quicker access to relevant facts • greater analytic capability • more staff involved in hunch building and testing	• too many facts to process • "forest and tree" problem • can encourage "group think"
Organizational structure	• more effective decentralization	• decentralization can get out of control
Costs	• overall cost reductions	• overall cost increase with vague benefits used as justification
Total impact	• planning of new approaches	• creates increased complexity and poorly functioning dependence relationships

Stallings (1987, 6)

Figure 2.

- psychology: Are workers receiving sufficient recognition? Are needs for achievement being met? Is there room for advancement?

- efficiency: Is the work exhausting? Is the degree of accuracy required excessive? Is sufficient information provided for maximum job effectiveness?

- task structure: Is there sufficient variety in the work? Are workers given enough scope to use their own initiative? Are they provided with a chance to make planning suggestions?

- ethics: Does management look after the interests of its employees? Do managers convey respect for the skills of the workers? How do workers perceive top management and its goals?

Step 2. Remember the Psychological Denial Processes at Work

When faced with problems, obstacles, and resistance, everyone develops denial systems. Anyone who has had positive experiences with technology tends to assume that everyone will want to become involved. Dealing with denial can be difficult. Steps to deal with denial include: encouraging discussion of the proposed changes, giving examples of how people might feel in meetings, and, above all, allowing time for free discussion. Find out how people really feel about their work situation and the equipment and technology they are using.

Step 3. Make Creative Use of Staff Assignment and Development Opportunities

Since not everyone will support change, the administrator can use the planning period prior to using a technological system to identify those work groups in the school (or system) who are either most interested, or most in need of the services such a system can provide. Few organizations will be able to bring their system up "all at once." The administrator can identify areas where current information flow is slowed (or even blocked) as well as areas where the departmental or work group is eager to get involved. Starting with such areas the administrator can involve several units in planning, pilot projects, or training. When work groups do a good job of utilizing technology, the administrator needs to be sure that they know how well they are doing. This "island culture" idea has been successfully used in many institutions and is celebrated in Peters and Austin's *A Passion for Excellence* (1985). If the people who are using the system are able to make it work and are enjoying it, other staff groups may want to get into the act.

Step 4. Deal with the "Curve of Nonsatisfaction"

The administrator needs to be aware of what Hannigan (1988, p.216) calls "the Curve of Nonsatisfaction" as workstation and local area networks continue to be used. This move toward nonsatisfaction with the system(s) is usually made up of:

- increased breakdown of hardware
- increased software failures
- increased data loss
- voiced dissatisfaction with software
- reported system slowdowns
- requests for additional and more complex data manipulation and reporting
- suggestions for purchase of peripherals
- increased requests for machine replacement
- requests for newer or enhanced versions of software
- reports of frustration because the system does not meet user needs
- breakthrough technology making equipment obsolete

Since this curve is inevitable, the administrator must evaluate system operations from the users' perspective and try to anticipate staff concerns and budget requirements for replacement, enhancement, and conversion to newer systems.

Conclusion

Staff participation in the planning of technology and in assisting with the selection of applications programs and standards provides a way of enriching the work life of the staff. People can have power. People can acquire information from other individuals working at their peer level in other institutions; people can acquire new and more complex skills; people can make good decisions about what applications to use for what purpose; finally, people can be rewarded. Such people will deal effectively with change.

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Evocative Encounters: Novice Adult Computer Users Learning About Learning

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Introduction

I've watched my children produce greeting cards, banners, posters and decorations with their home computer. I've stood by and watched them have all the fun without venturing to even touch the alien computer myself ("Carol," mid-forties).

To many adults, the personal computer seems to have rooted itself firmly within the culture of the young: toddlers to teens to twenty-year-old undergraduates. This may initially discourage or impede teachers' adoption of computer innovations.

How do adult computer novices regard and respond to the technology? One set of answers can be suggested by examining and interpreting six teachers' free-form personal journals, written while taking a semester-long software applications course.

Results

"Carol," "Francine," "Fred," "Monique," "Sam," and "Tammy" had similar computer use histories, attitudes, and motivations to learn. During the semester, they grappled with unsettling ideas of computers as both empowering instruments of human will, and intimidatingly competent, efficient producers of what was once uniquely human output. They made their own reluctance to change conscious so that they could transcend it, and, in the end, recognized significant shifts in work habits, learning styles, and collaborative interaction patterns.

Shifts in Learning Styles

The "trial and error" method is one that many educators recommend for their pupils, but often they then expect themselves to learn with little or no exploratory activity. They do not enjoy experiencing the ambiguity that is inherent in this type of learning.

Why don't [the directions] work for me? Well, actually they do work. But for me, it seems to be a "trial and error" episode. I have to try, fail! Then, try, fail again! But at the moment of total explosion, "it" seems to work. Whatever "it" is (Sam).

Computer experience seemed to increase these adults' tolerance for ambiguity.

....things don't always go as you had planned when using a computer. In fact, it's gotten to the point where I expect things not to work out, then I can't be too disappointed. When things do work out, then I can be happily surprised (Tammy).

Trial-and-error learning is really self-reflective experimentation, and the problem-solving competence that it can engender is essential to the lifelong learner's repertoire. Using so-called mistakes as data for problem solving is important, but can be confusing when dealing with an unknown such as the computer. Sometimes users must temporarily accept no explanation as the answer, since the *why* of what went wrong is not always as operationally cogent as the *how* to get the machine to do what one had originally intended it to do.

Self as Lifelong Learner

One element of our cultural notion of maturity is an assumption that children are more endemic, facile learners than adults. Unfortunately, that can also imply that adults are supposed to know everything already. Our society does not cultivate a developmental model of the adult as a lifelong learner.

The computer promises to save so much time, but at the same time makes each of us feel like babies again, learning to speak a language and walk all at the same time (Carol).

Yet to become comfortable and competent with computer tools, these students had to consciously grapple with the process of learning something entirely new. Some predicted personal change as a result of this struggle.

Frustrations and then realization and then accomplishment—a part of the growth process. I shall surely be a much more mature individual in December than I am now (Sam).

Not all of the students stated this expectation. Yet each of the six individuals wrote in hindsight of the most surprising subject of study.

Secretly I looked forward to this class because I knew that in it I would force myself to "learn computers." What I learned was a lot about myself (Carol).

These adults learned about what is human by contrasting it with what may appear to function similarly but is, instead, quite inanimate. Herein lay the summative surprise; learning what had first appeared to be a set of mechanical skills could additionally be experienced as a part of the journey to personal awareness.

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HYPERMEDIA

Introduction

The term 'hypermedia' has recently become popular for describing the use of multimedia technology combined with some type of program that will allow for far more interactivity than has been previously possible. The ability to utilize this technology has been made more accessible through programs like HyperCard for the Macintosh, LinkWay for IBM and HyperStudio for Apple computers. Uses for hypermedia are varied and innovative as the following articles describe. We should specifically note the potential for use with pre-service teachers in methods courses ranging from special education to physical education. Each author has found a unique niche in which to incorporate this technology.

Several of the authors have developed their own videodiscs to utilize in their program and these are described in the articles. Tannehill, O'Sullivan, Stroot, and Livingston describe the use of videodisc technology in a physical education methods course, utilizing a videodisc developed at Ohio State. Witherspoon, Barron and Goldman look at a hypermedia course for prospective elementary school teachers utilizing a videodisc, *Teaching Fractions*, which was developed as part of a series of videodiscs for use in elementary mathematics methods courses.

The articles also describe the use of hypermedia for the preparation of pre-service teachers. Morgan, Rule, Salzberg and Fodor-Davis discuss the utilization of hypermedia to prepare teachers to serve students with learning problems. Randolph, Smithey and Evertson describe a hypermedia program which highlights effective management practices for pre-service teachers. Marsh, Hofwolt and Sherwood discuss the utilization of videodisc technology in the area of science education for teachers. Several educational institutions are evaluating methods of incorporating technology into the curriculum. Golden describes a model in use at Marietta College in which hypermedia-based technology is utilized to provide a method in which to integrate technology across the education curriculum.

The remaining articles deal with other potential uses of hypermedia and technology. Perkins details the use of adapted hardware for use as an alternative input device which utilizes HyperStudio and the Adaptive Firmware Card for the Apple computer. Braswell provides an overview of *The Visual Almanac* and offers suggestions on how to begin to utilize these materials in your classroom. Reardon evaluates the use of a computer-based system in an audiovisual methods course. Yount, McAllister and Risko look at using technology as an alternative to a lecture approach to education. Finally, Thomson discusses the use of videotape evaluation in competency-based student teacher supervision.

As can be seen in the following articles, technology has found its place in education. As can also be seen in the following articles, the uses for technology are as varied as those who use it.

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Teaching Fractions: Using Hypermedia Contexts to Prepare Elementary School Teachers

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Observation of teachers and their students has been a critical component in the preparation of preservice elementary teachers because it provides contexts for the theory presented in university education courses. However, some researchers question the utility of such observations because the novices may misinterpret or fail to notice important aspects of classroom events (Berliner, 1986; Carter, Sabers, Cushing, Pinnegar, & Berliner, 1987). There are other constraints that limit the usefulness of actual classroom observations. The timing of the presentation of content at the university and in the schools may not coincide. Because each student may have seen a different lesson, they may not have a shared context for discussions. Are there other more effective ways to link theory and practice? At Vanderbilt University one effort, which was supported by the National Science Foundation, has been the creation of prototype hypermedia materials which present classroom scenes illustrating specific issues addressed in the elementary mathematics methods course.[1]

The first attempts of this project to bring elementary mathematics lessons into the methods course were through use of videotapes. The videotapes overcame some of the obstacles that complicate the constructive use of observations in the mathematics methods course. However, by their linear nature these proved somewhat inflexible and awkward (Goldman & Barron, 1990). For later offerings of the methods course, hypermedia modules were developed. Each module consists of a videodisc controlled by a Macintosh computer through a HyperCard stack which links specific segments on the videodisc with complementary text and illustrations. One advantage of these materials is the ability to isolate and access very quickly specific video information. Although the stack is quite structured, it is flexible in that branches of the stack can be taken in any order or omitted. Furthermore, the hypermedia is not limited to a presentation mode. Mathematics methods students have access to the information outside class.

One such hypermedia module is *Teaching Fractions* (Barron, Witherspoon, Bassler, Goldman, & Williams, 1989). This article will describe its contents and its use in the mathematics methods course. In addition, evaluations of the effectiveness of the implementation of the hypermedia modules will be summarized.

Contents of *Teaching Fractions*

The primary component of the videodisc is a set of two contrasting second-grade fraction lessons, both of which were taught by the same experienced classroom teacher. If one ignores the pupils and focuses only on the teacher, the "cake lesson" appears to be well-planned and executed. Management is exemplary. However, it becomes apparent early on that the pupils are very confused by the abstract introduction. The superficial use of only one concrete material, a cake, does not serve to clarify the concepts of one half and one fourth for most of the pupils. When they are asked to color in one half of each figure on a worksheet, many of the children are unsuccessful. Preservice teachers must analyze several aspects of the lesson, such as the pedagogical sequence, in order to determine why the pupils are having difficulty. On the other hand, in the "gum lesson" the teacher works through a variety of concrete and pictorial models before any symbolism is introduced. She makes efforts to tie the concept of half to the children's experience. Furthermore, she is aware of common misconceptions and attends to those. The pupils' responses and their written work give evidence of a greater level of understanding than in the "cake lesson." The remainder of the videodisc is filled with interviews with children, other classroom scenes, and samples of children's work that serve to illustrate various aspects of teaching fractions.

The main menu of the HyperCard stack offers several choices: contrasts between the "cake" and "gum" lessons, interpretations of fractions, representations of fractional number concepts, and misconceptions that children have (Figure 1).

The interpretations branch is based upon those enumerated in the text for the elementary mathematics methods course (Kennedy & Tipps, 1991). Work by Lesh, Post, and Behr (1987) is the basis for the representations section. The misconceptions branch is built around the observations in Witherspoon's (1989) master's thesis. Each choice on the main menu leads through a sequence of cards which provide various types of information, such as background that helps set the stage for a particular video segment, lesson plans and worksheets for the two lessons, references to literature, definitions, and questions that focus attention on salient aspects of a video segment (Figure 2).

Implementation of *Teaching Fractions*

The initial use of *Teaching Fractions* each semester is in a presentation setting. The mathematics methods professor uses the module as a lecture aid. The class meets in the computer lab where the students have access to machines with the HyperCard stack. The videodisc player is controlled by the professor, but the students follow along in the stack. The purpose of this initial setup is twofold: the students become familiar with moving around the stack and the professor has the opportunity to help frame their approach to thinking about the video scenes and the text on the computer screen. After one or two whole-class sessions, students have access to the stacks for independent investigation.

There are several emphases in the use of this video module. One is to expose students to a variety of teaching practices. Although the two lessons are taught by the same teacher, there are scenes with other teachers as well. The preservice teachers are encouraged to examine and reflect on the decisions made by each. Another is to provide very positive models. Several of the students have chosen to teach "gum" lessons as part of their

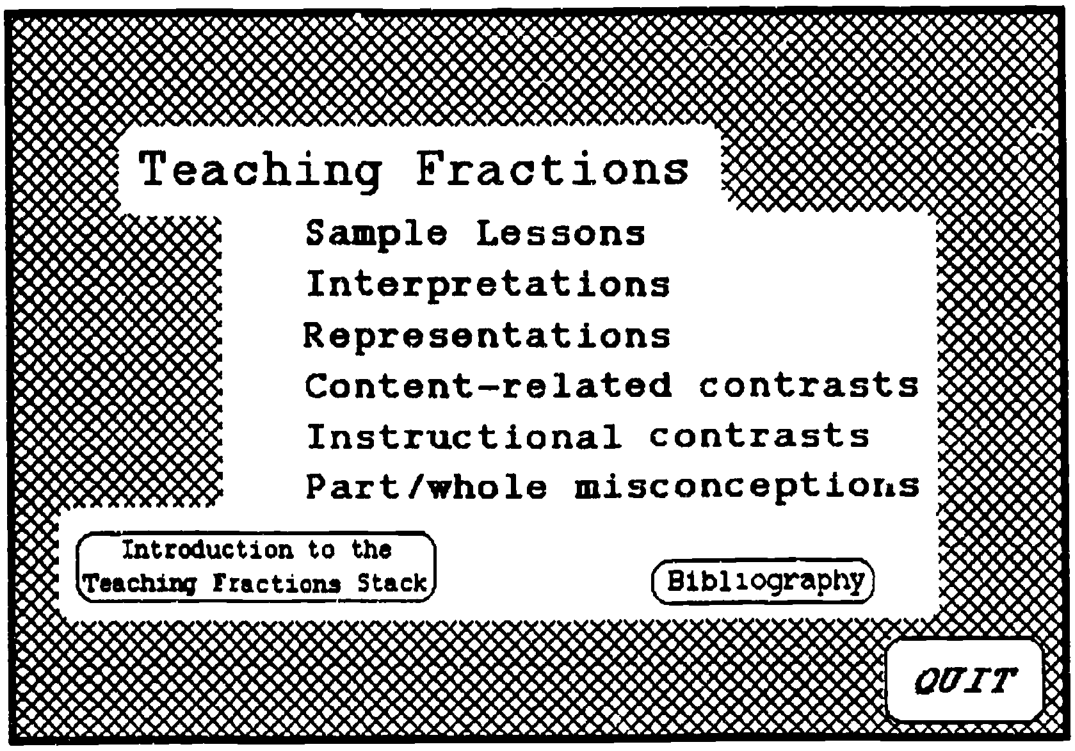

Figure 1. Main Menu of *Teaching Fractions.*

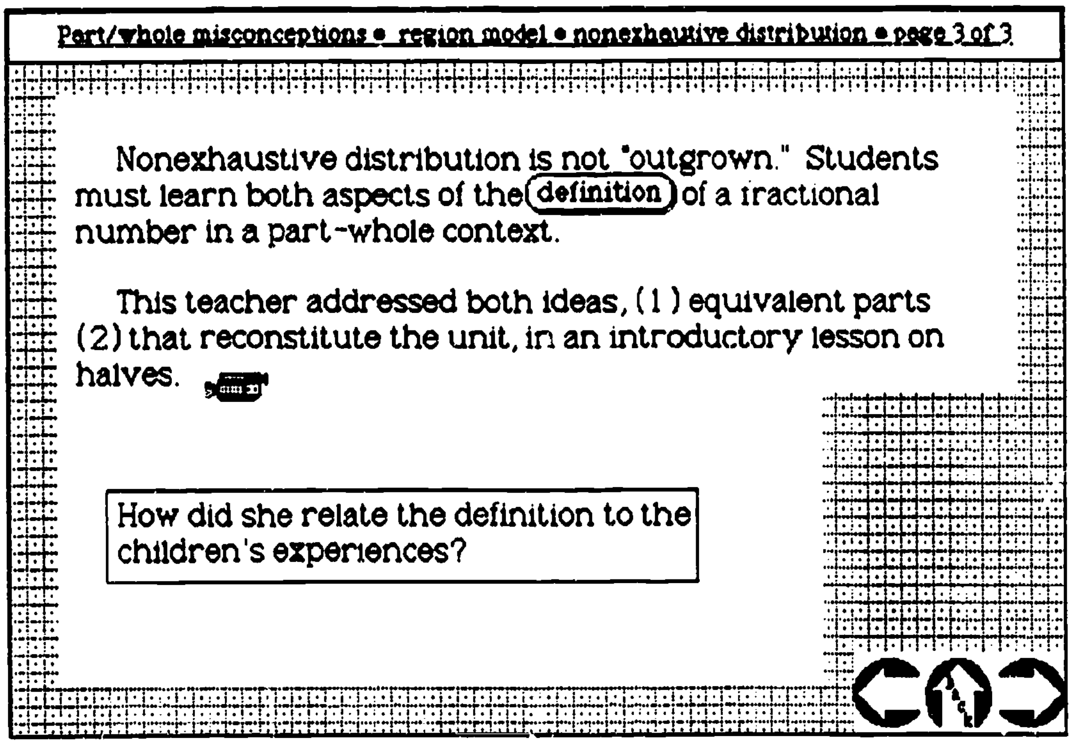

Figure 2. Sample card from the HyperCard stack, *Teaching Fractions*.

practicum experience. It is quite difficult for novices to take the research and implement it in lesson plans of their own. Modifying and teaching from an existing plan which is well-grounded might offer them a better chance of success. Perhaps the most important emphasis is that of reflection. The methods students are expected to analyze the lessons—the thinking that went into the planning and the decisions made on-the-spot in reaction to children's responses. Throughout the module the methods students must try to "get inside the pupils' heads." Not only must these preservice teachers decide whether a pupil's answer is right or wrong but they must also determine a rationale for the response. Such an emphasis is vital for preservice teachers who are quite preoccupied with their own performance. Some seem to feel that, if they execute the lesson plan well, their pupils will learn. Making them attuned to the thought processes of their pupils is of paramount importance.

Evaluation of the video components of the mathematics methods course

Teaching Fractions is only one of five hypermedia modules developed for and used in the elementary school mathematics methods course at Vanderbilt University. There have been several evaluations of the effects of their implementation. Berk's (1989) naturalistic inquiry case study reported that the students found the video illustrations helpful and the analyses valuable, that they felt the analysis of the video materials increased their confidence about teaching, that they felt more involved in the learning process with the hypermedia format than with a lecture format, and that they thought HyperCard was an effective instructional tool. In another measure, there was no difference between the methods course examination scores of the students who received the video-assisted instruction and those who did not (Goldman & Barron, 1990). Finally, the preservice teachers were rated on their teaching performance in the practicum which runs concurrently with the mathematics methods course. The rating instrument, which was developed specifically for the project, includes eight classifications of teaching competencies and two of pupil behaviors. The students who received the video components scored significantly better than those who did not in four teaching competency categories—basic skills development, development of higher-order and problem solving skills, management practices, and development of positive attitudes toward mathematics—and two pupil behavior categories—pupil involvement and on-task behavior (Barron, Goldman, Williams, Bassler, & Sherwood, 1989).

The limitations of the use of hypermedia have been in the time required to compose the materials, in the logistics of having to move the mathematics methods class in and out of the computer lab, and in the availability—or lack thereof—of the videodiscs to the students outside class. Thus far, multiple copies are only available for one of the videodiscs.[2] Because the others are one-of-a-kind "scratch" discs, they have limited availability for individual student use. While each HyperCard stack does contain useful information, it does not utilize its full potential without the videodisc.

Concluding comments

The hypermedia modules developed at Vanderbilt University have provided several advantages over standard observations. The classroom scenes are available at the instructor's discretion and provide a common context for the theory presented. Another benefit evidenced in *Teaching Fractions* is that negative examples like the "cake lesson" can be staged; thus, criticism is of the lesson—not of the person teaching the lesson. The hypermedia materials permit learning in the university classroom to focus upon the type of problem solving that teachers must do from day to day.

Footnotes

[1] This work was supported from 1987 to 1990 by Grant No. TPE-8751472. Additional staff on the project include Horace Williams, Otto Bassler, and Robert Sherwood, investigators, and John Harwood, programmer. Any opinions, findings, and considerations expressed in this article are those of the authors and do not necessarily reflect those of the National Science Foundation.

[2] The videodisc which has been mastered through the project is entitled *Teaching Subtraction*. For information about ordering this disc and the accompanying HyperCard stack, please contact Dr. Linda Barron, Box 330 Peabody, Vanderbilt University, Nashville, TN 37203.

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Videodisc-Assisted Courseware to Prepare Teachers to Serve Students Who Have Learning Problems

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Introduction

Elementary education teachers face the formidable task of instructing numerous students in a diverse array of subjects. This task becomes particularly challenging when some students present serious behavior and academic learning problems. In fact, teachers report that providing effective programs for students with problems is the most difficult aspect of their jobs, and the one that they feel least competent to address (Schofer & Duncan, 1982; Walker, 1979).

Description of the Videodisc-assisted Courseware for Teachers

This 3-year project developed and evaluated videodisc-assisted courseware to equip teachers with practical, classroom-based skills to develop and carry out individual intervention programs with students in their classrooms who displayed learning and/or behavior problems (Rule, Fodor-Davis, Morgan, Salzberg, & Chen, 1990). The courseware addressed curriculum-based assessment, behavioral assessment, behavior management, and maintenance strategies for academic and behavioral gains. In the course, teachers developed knowledge and skills to address academic and behavior problems. Further, the design of the course promoted collaborative problem solving among teachers as they developed and implemented programs for students with problems in their own classrooms.

Rationale for a Videodisc-assisted Field-based Course

To effectively instruct students with academic deficiencies or difficult behaviors teachers must individualize objectives and teaching methods. However, teachers report that they sometimes are ill-prepared to adapt instruction for students with diverse needs or significant problems (Schofer & Duncan, 1982). Also, even when teachers are adequately prepared, their overwhelming responsibilities to so many students in the classroom preclude individualized interventions. Given these circumstances, teachers need efficient and practical methods to help students with special needs.

The courseware developed in this project made training accessible to elementary school teachers. These teachers learned how to assess and alter problem behaviors, conduct curriculum-based assessments and design interventions based on these assessments. They worked with print materials, analyzed and discussed problems in their classrooms, and participated in videodisc simulations. Further, they designed and conducted programs for students with problems in their own classrooms based on the instructional strategies that they learned in the course. Finally, they helped one another by discussing issues and intervention approaches that they used in their respective classrooms.

Videodisc technology was used for several purposes: (a) to simulate field-based experiences in a classroom environment; (b) to show numerous examples of problems and techniques quickly and efficiently; (c) to allow teachers to repeatedly review video material as desired; and (d) to standardize the materials so that the course content would be comparable across instructors and locations. During the course, teachers interacted with the videodisc in numerous ways. For example, they watched video scenes and identified the techniques the instructor used, determined whether techniques were being used correctly, and discussed what alternative techniques might have been used. Other exercises required participants to observe students' behavior, define problems, write behavioral objectives, and practice recording occurrences of problem behaviors. A sample of videodisc simulations is described in Table 1. After simulation training, teachers applied procedures or strategies in their own classrooms. They planned and implemented these with supervision from the course instructors. They also received feedback from their colleagues in class and revised their programs accordingly.

Field Test of Courseware

Field testing occurred over a two-year period. This section describes the participating teachers, students, course content and activities, and the instructors who taught the course. Also, the teachers' interventions and the outcomes are described.

Participating Teachers

Thirty teachers from elementary schools in Utah and Minnesota participated in five classes taught from 1987-1990. Teachers' experience ranged from one to 27 years (average = 6.5 years). They included eight 3rd grade teachers, seven 1st grade teachers, five 4th grade teachers, three kindergarten teachers, and two 2nd and 5th grade teachers. Classes ranged in size from three to eight teachers.

Students

Twenty-eight students participated in the classroom interventions developed and implemented by the teachers. They included 18 boys and 10 girls from 5 to 10 years old (mode=9 years). Each student was identified by a participating teacher as displaying severe academic and/or behavior problems and was considered "at-risk" for referral to special education services. For some students, the teachers' assessments and intervention programs were pre-referral interventions which could lead to special education placement if academic or learning problems were not effectively addressed, or if additional services were needed.

Course Content

Course content was primarily derived from two sources: (a) research literature on treatment of academic and behavioral problems of students in regular classrooms; and (b) responses to a printed survey distributed to

Table 1
A Sample of Videodisc Simulation Exercises

Content Area	Description of Exercises	Objective
Specifying Behavior	Teachers watch a scene showing a student named "Mike" who slams the classroom door, slumps in his chair, and refuses his instructor's assistance.	Teachers specifically identify the problem behavior(s) and the preferred alternative(s).
Behavioral Assessment	Teachers watch a classroom scene showing a student named "Dan" during an independent seatwork period. He alternates between working on his math assignment and looking around the room.	Teachers use a system to measure Dan's on-task behavior.
Behavioral Intervention	Teachers watch scenes of a student named "Raymond" who has academic and behavioral problems. His instructor describes an assessment of Raymond's problems and some intervention procedures used in attempt to solve them.	Teachers collaborate to design academic and behavioral interventions for Raymond.

Table 2
Summary of Teachers' Interventions with Students who had Learning and/or Behavior Problems

Class	Student's Age/Grade	Target Problem(s)	Outcome(s)
Fall 1988	7/1st	(a) Disruptive and aggressive behaviors; (b) inattentive to tasks.	(a) Disruptive behavior decreased; (b) attention to tasks increased.
	9/4th	(a) Inattentive to tasks; (b) poor sight word recognition.	(a) Attention to tasks increased; (b) sight word recognition increased.
	6/K	Low level of following instructions.	Instruction-following increased.
	8/2nd	(a) Inattentive to tasks; (b) poor oral reading.	(a) Attention increased; (b) no data reported.
	9/3rd	High error rate in math.	Math accuracy increased.
	6/1st	No identification of letter names or sounds.	Decoding of words and blends increased.
	8/3rd	Low level of assignment completion.	Assignment completion increased.
	10/5th	(a) Inattentive to tasks; (b) poor knowledge of basic math facts.	Insufficient data on (a) and (b).
Spring 1989	8/2nd	Delays in reading rate and accuracy.	Insufficient data.
	10/4th	Inattentive to tasks.	Attention to tasks increased.
	5/K	(a) Inattentive to tasks; (b) low level of assignment completion.	(a) Attention to tasks increased; (b) assignment completion increased.
	10/4th	(a) Delays in reading rate and accuracy; (b) inattentive to tasks.	Insufficient data on (a) and (b).
	7/2nd	Disruptive and aggressive behaviors.	Insufficient data.
Winter 1990 (Utah State)	6/K	(a) Inattentive to tasks; (b) sound and letter identification.	(a) Insufficient data; (b) no change.
	9/3rd	Poor math computation skills.	Computation skills improved.
	9/3rd	(a) Poor math computation skills; (b) accepting correction.	(a) Computation skills improved; (b) acceptance of correction improved.
	9/4th	Inattentive to tasks.	Attention to tasks increased.
	9/3rd	Inattentive to tasks.	Attention to tasks increased.
	9/4th	Reading comprehension.	Reading comprehension improved.

Winter 1990	7/1st	Inattentive to tasks.	Attention to tasks increased.
(St. Cloud	6/1st	Inattentive to tasks.	Attention to tasks increased.
State)	9/3rd	(a) Reading comprehension; (b) low level of class participation.	Insufficient data on (a) and (b).
Winter 1990	10/5th	Poor math computation skills.	No data reported.
(Utah State)	Age not reported/3rd	(a) Poor decoding skills; (b) inattentive to tasks.	Insufficient data on both (a) and (b).
	6/1st	(a) Poor sight word recognition; (b) inattentive to tasks.	Insufficient data on both (a) and (b).
	8/3rd	(a) Poor decoding skills; (b) talking out without raising hand.	(a) Decoding skills increased; (b) talking out decreased.
	6/1st	Poor identification of letters and sounds.	Identification skills increased.
	6/1st	(a) Poor number counting skills; (b) inattentive to tasks.	(a) Counting skills increased; (b) attention to tasks increased.

an advisory committee which assisted in development of this course. Syntheses of the information from the literature review and advisory committee responses led initially to the development of courseware with four units: (a) principles of effective instruction; (b) curriculum-based assessment; (c) behavioral assessment; and (d) design of effective interventions. Later, feedback from participating teachers led to the development of a fifth unit, i.e., maintenance of student's newly-acquired skills.

Course Activities

The course lasted 10 weeks, corresponding to the university's academic calendar. In class sessions, teachers discussed the problems of students that were of greatest concern to them. They also practiced assessment and intervention strategies, collaborated with one another in developing their academic and/or behavioral programs, and presented the results of their interventions. Teachers carried out assessment and intervention assignments in their own classrooms. Further, they were assigned case studies to read each week. The major assignment for the course was to select one student with a significant academic and/or behavior problem, assess that student's problem, develop an intervention, carry it out, revise it as needed, and write a summary of the case describing the problem(s), the instructional content, the intervention program, and the results.

Course Instructors

The first two classes (i.e., fall 1988 and spring 1989) were conducted at Utah State University by instructors associated with the project; the remaining three were taught by instructors unaffiliated with the project. One of these was conducted by an assistant professor in the Department of Psychology, St. Cloud State University. The other two were conducted at Utah State University by doctoral students in the Department of Special Education.

Review of Teachers' Interventions

Table 2 presents a summary of the interventions. A total of 28 interventions for individual students were implemented by 30 teachers in the five classes. Two teachers in one class collaborated on one intervention. One other intervention was carried out, but no written report was received and the outcome was not verified

As shown in Table 2, teachers identified numerous academic and behavioral problems. The most common problem was "inattention to tasks," which was identified in 15 of the 28 interventions. Thirteen interventions targeted more than one academic and/or behavior problem. For example, many interventions targeted both an academic problem (e.g., poor sight word recognition) and a behavior problem (e.g., inattention to tasks).

Numerous procedures were included in the teachers' interventions. Many consisted of several interrelated strategies. Some teachers modified their intervention procedures during the course as need dictated. Review of a sample of the teachers' written summary reports by project staff indicated that all interventions included baseline and/or curriculum-based assessment data so that the students' level of performance was evaluated prior to intervention. All participants met with the student to negotiate intervention procedures (e.g., identify incentives, determine how incentives could be attained, establish academic or behavioral objectives). Most interventions included a teacher-student agreement, or "behavior contract."

Interventions for Academic Problems

Academic intervention procedures included (a) individualized performance criteria, (b) increased opportunities to respond, (c) increased monitoring of performance by the teacher, (d) peer tutorials, and/or (e) self-monitoring procedures, among others. As mentioned earlier, many intervention programs used a combination of procedures which changed sequentially through the project.

Interventions for Behavior Problems

Behavioral interventions included (a) incentive procedures for individuals or groups of students, (b) token reinforcement procedures (e.g, point systems for earning incentives based on good performance), (c) audio signal cassette tapes that allowed teachers and students to monitor attention to tasks, (d) self-monitoring systems, and (e) peer assistance procedures, among others (see Alberto & Troutman, 1982, for review). For example, in one common type of intervention, students earned points if they were attending to tasks when a tone sounded (produced at variable intervals by an audio tape). These points were later exchanged for preferred activities.

Table 2 summarizes intervention outcomes by indicating whether each student's skills (a) met the stated objective or was trending toward that objective (e.g., positive outcomes), or (b) did not trend toward the stated objective (i.e., unsuccessful or negative outcomes). For example, if a teacher's data indicated that an intervention increased a student's attention to task, this intervention outcome was considered "positive," even if the objective had not yet been met. However, if a teacher reported that an intervention had not increased math computation skills as planned, then the intervention outcome was considered "negative." Some teachers' programs had not been implemented or had been implemented just prior to submission of the final written report and therefore could not be evaluated (i.e., insufficient data). These programs with insufficient data are identified in Table 2. Using this informal analysis of the 28 intervention outcomes, 19 were positive (68%), 8 (29%) had been implemented for too short a time to evaluate, and 1 (3%) had produced negative outcomes.

Discussion

These data show that elementary teachers were able to implement academic and/or behavioral intervention programs in their classrooms with students having learning problems, and that over two-thirds of these programs produced positive results in a relatively short time. Some teachers were delayed in starting their intervention programs or had insufficient data to evaluate their program at the end of the course. A 10-week quarter proved to be a very short period for teachers to acquire skills and apply them to the design and implementation of individualized intervention programs. Nevertheless, these results across five classes show that many participating teachers produced successful outcomes.

Our findings suggest that the videodisc-assisted courseware, in conjunction with the collaboration model, equipped elementary teachers with the basic skills necessary to more successfully integrate and maintain students with learning and behavior problems in their classroom. While the evaluation is limited by the absence of experimental controls or follow-up data, it provides preliminary evidence that this courseware can help many teachers manage classroom problems. Additional research is necessary to compare the effects of videodisc-assisted courseware with other procedures designed to help teachers with classroom problems and to identify the long-term effects on teachers' skills in managing these problems.

This article examines just one method of courseware evaluation—an examination of teachers' interventions. Examinations of the interventions indicates that technology-assisted courseware can impact both classroom teachers and classroom learners. Other evaluation methods, such as teachers' performance in the course and their perceptions of materials, indicate that they enjoyed the course and found it useful. The courseware provided sufficient examples to assist participating teachers to identify and use simple interventions that were appropriate to their needs. However, the technology was not a substitute for an expert instructor, who was qualified to assist teachers in designing interventions for the diverse problems that they identified. Neither was the courseware a substitute for an active group of participating teachers who could assist one another through discussion and analyses of problems. The videodisc simulations, however, provided an array of visual and audio materials necessary to teach the course. It allowed instructors to devote time to providing individual assistance and feedback rather than to extensive preparation of course material.

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Using *HyperStudio* to Create Lessons that Use Alternative Input Devices

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Introduction

Hypermedia programs such as *HyperStudio* can empower handicapped individuals by teaching as well as by providing automation to tasks that hinder the individual. A hypermedia file, or stack, contains screens with three primary features: text, graphics, and buttons. Text (words) and graphics (pictures) are common in computer software, but buttons are what add the real power to these programs. For the student, pressing a button within a stack can make magical things happen. At the press of a button, the computer may link to another card and present new text or graphics; it might register a choice made by the student and react dependent on the choice made; or, other devices may be controlled by the buttons such as sound digitizers and laser videodisc layers (Van Horn, 1991).

With special populations, obtaining programs that teach specific objectives may be impossible. Hypermedia programs provide the power for educators to tailor specific lessons for individuals by using these programs as an authoring language (Van Horn, 1991; Church & Bender, 1989). Non-programmers can create computer programs without learning computer programming.

The primary input device for hypermedia programs is a mouse. For most first-time computer users, a mouse requires a certain amount of manual dexterity, eye hand coordination, and much practice (Lahm & Greszco, 1988). It is also an indirect pointing device; those using it must learn the connection between the mouse on the table and the arrow on the screen (Alessi & Trollip, 1991; Lahm & Greszco). A mouse provides accurate and reliable pointing, but many disabled individuals are unable to use it.

HyperStudio has two features built in that increase the accessibility of stacks created by it to individuals who require adaptive input devices. The first feature is that *HyperStudio* has the capability of recognizing the presence of a *TouchWindow* to help eliminate the indirectness of the mouse. The second feature that *HyperStudio* has that makes it useful is a feature called auto-activated buttons. These buttons are programmed to activate themselves after a specified amount of time and will help eliminate accessibility problems to the physically disabled.

Cognitive or Minor Physical Disabilities

For those individuals who cannot make the connection between the mouse on the table and the pointer on the computer screen, or those with minor physical disabilities, the *TouchWindow* is an excellent solution. A *TouchWindow* is a clear plastic membrane that can be attached over the computer monitor. It provides direct contact with the computer screen and buttons within the program (Alessi & Trollip, 1991; Male, 1988).

To activate the *TouchWindow* in *HyperStudio*, make sure that it is securely mounted to the computer monitor and plugged into the joystick port. After booting *HyperStudio*, use the mouse to choose the Apple icon in the Menu Bar across the top of the screen. Choose PREFERENCES from the menu. There will be a box with "Use *TouchWindow*" next to it. Click on this box to activate the *TouchWindow* and press OK.

A *TouchWindow* must be calibrated for the screen that it is mounted to. The "*TouchWindow* Calibration" screen will appear with instructions. After clicking OK, you will be asked to touch the top left corner of the screen until a beep sounds, and then the bottom right corner until a beep sounds. It is very important that this be done looking directly from the front of the screen, and not from an angle, otherwise, the *TouchWindow* will think you have a different size screen and will not recognize the buttons as they are pressed. *HyperStudio* will now recognize the *TouchWindow* as the input device with any stacks that are created. The mouse is also still active, but sometimes is erratic in its movement. For those not using the *TouchWindow*, it is best to go back to the Apple Menu and, under Preferences, deactivate the *TouchWindow*.

Serious Physical Disabilities

Computer input for physically disabled individuals is limited by their control of input devices. Physical disabilities range from complete control of one hand to control of only one muscle or muscle group. These individuals must use the capability that is least restrictive in nature but provides the easiest access and speed for computer input. The simplest method of input that deviates from the norm is the best (Lahm &Greszco, 1988).

Scanning

For students without the ability to touch different parts of the screen, an alternative is necessary. Scanning is a process where the possible choices available to a student are shown on the computer screen, and a cursor moves through the choices. When the preferred choice is highlighted, it is selected by a switch press or mouse click (Green & Brightman, 1990). Students do not have to move a mouse or type in their response.

HyperStudio can be used to create lessons that scan through the choices rather than having to move the mouse to the preferred choice. Scanning is no more than a menu that cycles through the possible choices. This menu is made up of a series of cards, all with the same choices on it, but with one of the choices highlighted by having it different from the others. On each card is two buttons, one to register a mouse click and one to automatically go to the next card if there is no activity in a specified amount of time.

Auto-activated buttons are used to create scanning stacks where the cards are changed automatically and the student presses an input device to make a choice. The user sees the highlighting go from one choice in a menu to the next (the auto activate button). The scanning allows the user to click when the choice wanted is highlighted. If no item is selected in the series, the process goes back to the first card in the series. If the mouse click is registered, then that item is selected and the user moves out of that menu. This minimizes the amount of input activity required from the user.

To create a scanning series in *HyperStudio*, decide what the menu will look like and what the choices will be. For this example, a simple multiplication drill will be created. It will have the problem "2 X 2 =" and the choices 4, 5, and 6 as possible answers. Using the text tool, type the problem at the top of the screen and the three possible answers at the bottom of the screen. Once the screen is exactly as it should be, use the EDIT menu to COPY CARD, and then again from the EDIT menu, PASTE CARD as many times as you have possible answers (Card 1, Card 2, and Card 3 in this example). You should also create a Correct Answer card (Card 4) and an Incorrect Answer card (Card 5) to provide the student with feedback regarding their answer.

MOVE to the first card in the series. Each card must be distinctive by the choice that each card represents. The first card represents the correct answer as "3". On that card, use the rectangle tool from the TOOLS menu and draw a rectangle around the 3. MOVE to the next card and draw a rectangle around the 4, and on the next card around the 5. By flipping through the cards, it will appear that the rectangle is moving across the screen.

Now MOVE back to the first card in the s[illegible]s. It is necessary to place buttons to allow the lesson to be operated. Scanning menus require two buttons per page, one to register the students choice, if it is input, and one to move to the next screen after five seconds if there is no student response. Buttons are created under the OBJECTS menu by choosing Add a Button.

The first button will automatically go to the next card (Card 2) after a specified amount of time. Choose Add a Button from the OBJECTS menu. *HyperStudio* allows you to create invisible buttons by choosing that icon and then press OK. The button appears as a rectangle in the middle of the screen. Since it is an auto-activate button, it is best to make it small and place it in a corner (so that it does not accidently get pressed by the operator of the program) by putting the mouse arrow on one corner, holding the mouse button down, and moving toward the middle of the button using the mouse. When it is small, put the mouse arrow in the middle of the button, hold down the mouse button, and drag the button to a corner. Move the mouse arrow outside the button and click the mouse to indicate to *HyperStudio* that the button is finished.

HyperStudio needs to know the actions that this button will perform. This button will be linked to the next card. Under CONNECT TO, choose "Another Card." Using MOVE from the pull-down menu, choose "Next Card" and then press OK. Visual effects to happen during the card change can be specified now. This button needs to have "Auto-activate after delay" selected, and change the "Delay in seconds" to an appropriate time (5 seconds). Press "Done" to conclude creating this button. This type of button needs to be created for each of the cards in this series. The last card (Card 3) will be linked to the first (Card 1) to complete the cycle.

For this exercise, two of the answers are incorrect, 3 and 5. On the cards with those as the highlighted answer (Card 1 and Card 3), another invisible button needs to be created. This button, however, will cover almost all the screen (it cannot cover the whole screen because there must be an area to click the mouse outside the button to indicate the size and placement of the button is finished). First move the button to a corner and then drag the corner of the button to cover most of the screen using the same process used on the auto-activate button.

This button is not an auto-activate button. It does, however, link to the card that provides incorrect-answer feedback (Card 5) concerning the problem. Choose Connect to and "Another card", and again, use the MOVE menu to find Card 5. This same process will be done using the card with 4 as the answer, but it will be connected to the correct-answer card, which is Card 4. The incorrect-answer card could have an auto-activate button that links back to Card 1 in the series. The correct-answer card could move to another problem.

The last step after the lesson has been created is to go to the Apple menu, choose Preferences, and turn on the Auto-Activate buttons. This should be done only after the lesson is complete or only to try the series just created and then turned off. If auto-activate is on during the authoring stage, the cards will start changing as they are being created, causing much confusion.

Using an Auto-activate button combined with a very large button on each screen will allow the student to just be able to click the mouse to make choices. *HyperStudio* will automatically operate card changes until the student clicks the mouse. This process does require that students minimally be able to click the mouse, however.

The *Adaptive Firmware Card*

Students who have control over only a single muscle or muscle group may not be able to operate a mouse button. They may require specific switches that take advantage of that muscle or muscle group to operate a computer. Alternative input devices for computers fall into two groups: those that require special programs that recognize the device (e.g. the *TouchWindow*), and those that are transparent to the program. Transparent devices will work with almost all programs (Lahm & Greszco, 1988) but do require an interface card to translate the input into information that the computer can recognize. The most common device for this is the *Adaptive Firmware Card* (AFC). It will accept input from any switch, a mini keyboard, a Unicorn keyboard, and many other ASCII devices and alternative keyboards. Since the AFC is transparent, no special instructions need to be given to *HyperStudio* to recognize its existence.

The AFC addresses mouse input using mouse emulation, but this requires a switch press to do each of the following to make a choice: aim the mouse, move the mouse, stop the mouse, and click the mouse button. Using the self-activating buttons in *HyperStudio*, part of this process can be automated and controlled by the computer. Because of the complication of using a switch for input, the AFC manual states "Avoid mouse emulation...Look for keyboard equivalents" (*Adaptive Firmware Card* Operator's Manual and Application Guide, 1988, p.18-3). Rather than have the switch control mouse movement, *HyperStudio* can eliminate the need for mouse movement. Using the lesson previously created, the AFC will convert a switch press to a mouse click.

Using the AFC's own mouse switch-input scanning method still requires two switch presses to make a choice, one to have the AFC expect mouse input and one to click the mouse. A way to reduce the number of inputs was necessary to make this process more efficient. The AFC has the capability to use Morse Code as an input method. By designating an "E" and a "T" in Morse Code as a mouse click, a single input can do both of these steps ("E" and "T" were used to allow either a short or a long switch press to be recognized as a click).

To create a new setup for the AFC, the Menu Construction Disk that came with the AFC is used. Boot the disk with the AFC turned off (the program will indicate when it should be turned on). The steps necessary to create a Morse Code AFC setup that is used just to click the mouse button using a switch are as follows:

1. Move the highlighting to the Morse Code setup and press CTRL-C to make a copy of this setup without changing the original.
2. Press return on the setup to Copy it.
3. Choose MAKE CHANGES TO THIS SETUP.
4. Choose DESCRIPTION and make changes to suit the purpose that this setup will be used for, e.g., "TITLE-HyperStu", "METHOD-Morse 1 SW", and "FOR HS.Button clicking", and then save the changes.
5. METHOD-choose MORSE 1-SW HI/LOW if you would like sound to indicate a "dit" changing to a "dah" or MORSE 1-SW PLAIN for no sound. RATE

is the rate that the student must release the switch before a dit becomes a dah—the higher the number the faster the change. The current rate of 7 is adequate, but it may need to be reduced for someone who is slow to release the switch.

6. The SPECIAL OPTIONS menu needs the following changes
   AFC Macros=on
   Mouse/Joystick=on
7. The OVERLAY menu needs changes to translate switch input into a mouse click. Choose WORK WITH OVERLAY. Setting up this requires that key input indicate the code user sends: press the period for a "dit." The message that the "COMPUTER RECEIVES 'E'" will appear. Choose "2. Modify 'Computer Receives'." Delete the E, press ESC to get special characters, choose <AFC.MOUSE>, then type "C" and press Return (C is for clicking). What appears is "<mouse>c". Proceed to next code which is the minus sign (dah) and change it so that it is also "<AFC.MOUSE>C". This changes the switch input so that an E (dit) or a T (dah) is recognized as a switch press and will act as a mouse click.

Use the TRANSFER option from The Menu Construction Disk to save the setup on the AFC Quick Start Disk. Boot the computer with the AFC Quick Start disk. After being instructed to turn the AFC on, choose the method just created. Boot *HyperStudio*, turn on the Auto-Activate buttons, and the lesson will work using a switch for input.

Conclusion

There are other features that make *HyperStudio* an excellent program. It comes with the ability to digitize sound (a sound digitizing board and microphone come with the program), it has the ability to control a laserdisc player to create interactive videodisc lessons, and it has the ability to recognize the Apple Video Overlay Card so that only the computer monitor is used instead of a separate TV for the videodisc player. These features are useful for all lessons, but especially for special individuals. *HyperStudio* can create a menu that does all of the following: operate a lesson, become a talking word board, launch another *HyperStudio* stack, or launch another application (such as AppleWorks).

The optimum equipment setup for a physically disabled individual would be an Apple IIgs with at least 1.25 meg. of memory (*HyperStudio* requires at least 1.25 meg.), at least a 3.5" disk drive, but a hard drive would be better in situations where multiple applications or numerous sound and graphic files are used, the *Adaptive Firmware Card*, and the necessary switch.

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Observing in Secondary Classrooms: Piloting a Videodisc and HyperCard Stack for Secondary Methods Students

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Classroom observation can be thought of as a way of seeing, where what is seen depends on what is looked for (Evertson & Green, 1986). The problem for novice observers is to know what, of all the activity in a busy classroom, is important enough to be noticed. Novice teachers lack the context for their observations which more experienced teachers have; they are likely to miss or misinterpret what they see (Goldman & Barron, 1990). One area where such omissions and misinterpretations may occur is in classroom management. Because first-year teachers perceive classroom management as their greatest concern (Veenman, 1984), further attention to this area in teacher preparation programs is necessary. Classroom observation and analysis can be a useful tool. However, the complexity of managing a secondary classroom is sometimes hidden from preservice teachers when they observe in smoothly-functioning classrooms. Management procedures which are working best may in fact be the least visible. The purpose of this project has been to highlight effective management practices through the use of videodisc and an accompanying HyperCard stack. The videodisc consists of examples from real classrooms which illustrate how effective planning for management underlies smooth classroom operations, and which highlight the management decisions teachers make during a class period.

Videodisc and Stack Development

Material for the videodisc came from nine hours of videotape made in three middle school classrooms (one classroom each of reading, science, and mathematics). Teachers were chosen on the basis of their experience, reputations for effective teaching, and good working relationships with the university. Whole class periods were taped, with no attempt at scripting.

Extensive review of the tapes followed. While we had expected to capture off-task behaviors that even these expert teachers had missed, in fact we saw very little unsanctioned activity. It was clear that the management strategies that these teachers were using were effective in preventing off-task behavior, and we began to look for episodes which would highlight those strategies. Two videodiscs resulted. The first consists of isolated incidents from the three classrooms, to be used in defining management behaviors. The second contains one edited lesson from each of the three classrooms; its function is to allow students to see how management decisions are embedded within a full class period.

The HyperCard stack (Evertson, Myers, & Randolph, 1990) guides students through examples organized under ten concepts: starting class; rules and procedures; overlapping and withitness; handling distractions; praise; monitoring; giving directions; checking understanding; classroom culture; and ending class. Each concept begins with presentation of a definition, after which users select an example of the concept to view. Text describing the scene supplements the video example. Each example is followed by open-ended discussion questions and ideas for preservice teachers to incorporate into planning for their own classrooms. For each concept, possible assignments for classroom observations are provided. The stack is designed for use either by an instructor leading a whole class, or by individual students or small groups working independently in a learning lab setting.

Throughout the development of the videodisc and stack, an attempt was made to avoid the implication that teachers' decisions can be neatly categorized as "good" or "bad." Instead, the emphasis was on the examination of options open to a particular teacher at a particular moment, and the likely results of each course of action. While one purpose of the materials was to simplify the complexity of the classroom by making management more visible, we felt that it would not be helpful to deny that the complexity exists, or to imply that management is a simple linear process of right and wrong decisions.

Effects on Learning

The materials were evaluated in a pilot study, completed in an introductory foundations of education course, which asked the following questions:

1. Does the use of videodisc/HyperCard technology increase preservice teachers' knowledge of classroom management concepts?
2. Does the use of videodisc/HyperCard technology increase preservice teachers' ability to observe and/or interpret classroom activity?

Methods

Sample

Thirty students enrolled in the introductory foundations of education course at a local college constituted the sample for the study. Seven students were absent on either the pre- or post-test day, leaving a final sample of 23. Seventeen of the students were randomly assigned to one of two treatment groups. Six students with prior observation or teaching experience were matched and then randomly assigned to one of the groups. The limitations of the small sample size were recognized, but for this preliminary study the value of having all participants with approximately the same pre-treatment exposure to education courses was deemed to outweigh the disadvantages.

Treatment

Students received 45 minutes of instruction on classroom management concepts of overlapping and withitness, effective praise, rules and procedures, handling distractions, and monitoring, either in traditional lecture/discussion format ("lecture" group; n = 11) or in lecture/discussion format supplemented with HyperCard text and videodisc examples ("video" group; n = 12), during their usual class meeting time. Both instructors worked from the same outline in presenting information. Prior to the treatment, none of these concepts had been introduced in the class, and students had not yet begun observing in classrooms.

Measures

Students were pre- and post-tested on an objective and an analytical task. In the objective task, students were asked for a definition and an example of each of the classroom management concepts (e.g., Overlapping is when the teacher accomplishes two or more tasks at once; for example, she takes roll and collects homework). Definitions and examples were scored separately on a scale of 0 (absent or incorrect) to 2 (correct, complete, and specific). In the analytical task, students were shown three minutes of video tape of a middle school classroom, and asked to write a narrative account. Directions for this task were deliberately vague: students were simply told to "write what you see." The same video was used for both the pre- and post-test. The resulting narratives were scored on a scale of 1 (low) to 5 (high) along four dimensions:

1. Completeness: Inclusion of major and minor events.
2. Detail: Specificity of description.
3. Description/Interpretation: Narratives which were most or all description versus those which were most or all interpretation.
4. Use of Concepts: Extent to which narratives demonstrated application of the concepts presented in the treatment.

All dimensions were scored independently by two raters who were blind to the treatment condition of the subject. The two scores were averaged if they were within one point of each other; if there was a larger discrepancy between scores, the difference was resolved by discussion to 100% agreement. Additionally, a word count of all narratives was conducted ("Length").

It was hypothesized that both groups would show improvement on all measures, but that the video group would show more improvement. For each measure, the two pre-test groups were compared using z-tests to be sure that random assignment had not resulted in pre-test variation. Post-test scores for the two treatment groups were also compared using z-tests. Pre- and post-test scores within each treatment group were compared using t-tests for related measures. One-tailed tests were used in all cases, with a significance level of .05.

Results

Objective measures

As predicted, both groups improved significantly from pre- to post-test. Video group post-test scores were significantly higher than lecture group post-tests. That is, the use of video technology resulted in significantly higher ability to produce definitions of the concepts covered

On the examples task, again as predicted, both groups performed significantly better on the post-test than on the pre-test. Pre-test groups, however, started out significantly different from each other; by chance, members of the lecture group scored significantly lower than members of the video group on the pre-test. Therefore, statistical comparison of the two post-test scores would not be meaningful. Comparison of the gain scores for the two groups, however, does suggest a difference. The lecture group improved from a pre-test mean score of .46 to a post-test mean of 4.08, an increase of less than two examples. The video group improved from a pre-test mean of 2.0 to a post-test mean of 8.86, a gain of more than three examples. This difference is an important one. Students who are able to provide examples of a concept show evidence that the concept has been internalized, and mental images formed; these students would be expected to be more able to match their mental images with events they observe in classrooms.

Analytical Measures

Pre-test groups were not significantly different from each other on any of the analytical measures, with the exception of Detail; thus, on all dimensions except Detail, lecture post-test scores can be compared to video post-test scores.

Lecture pre- and post-tests did not differ in terms of Length. This was surprising; we had expected that the mere fact that subjects were seeing the video for the second time would result in longer narratives. Video post-narratives, however, were significantly longer than video pre-narratives, and were significantly longer than lecture post-narratives. Video group students thus wrote more than did lecture group students.

Few differences were found on the dimensions of Completeness and Detail. There were no significant findings on Completeness. On Detail, lecture groups scored significantly higher on post-tests than on pre-tests. There were no other significant findings on this dimension.

Subjects were likely to be more Interpretive in post-narratives than in pre-narratives, regardless of treatment group. There was no significant post-test difference between treatment groups.

While students in both treatment groups scored higher on Use of Concepts on post-tests than on pre-tests, no significant difference was found between treatment groups on the post-test. The difference, however, did approach significance ($p = .06$).

Discussion

Preservice teachers instructed in classroom management concepts using a lecture/discussion format supplemented by videodisc examples and HyperCard text wrote better definitions of the concepts and longer narratives of classroom events than did those instructed with a traditional lecture/discussion format. There is also evidence that video group students were more able to provide examples of concepts, and were more likely to use concepts in narrative descriptions of classrooms, although these findings were not statistically significant.

While these results must be viewed as tentative due to the small sample size, the fact that any findings were significant given the relatively short treatment length points to the value of further exploration of these questions. The near-significant difference on the Use of Concepts measure is especially intriguing given the other findings. Video group subjects wrote more than lecture group subjects, but this difference is not accounted for in terms of completeness or detail. Then, what more did they write? This group also demonstrated better knowledge of definitions of the concepts covered, and there is some evidence that they were more able to give examples of concepts. Perhaps they used their knowledge of concepts to see more and therefore write more.

The tentative results from this study suggest that further exploration of the effects of the method, with larger samples sizes and longer treatment periods, would be worthwhile. The effects of using the videodisc/HyperCard stack should be compared to the effects of using video tape. After all, the findings reported here that visual examples are more effective than written or spoken descriptions of examples are not exactly surprising. Perhaps video tape would be just as effective as the more expensive and less available videodisc. Certainly the videodisc is more convenient for the instructor; is it also more effective? The higher precision of the videodisc for isolating selected aspects of an event, combined with the potential for flexibility in linking examples offered by HyperCard, may provide students with more specific, more tightly focused examples, and thus be more effective.

Further studies are needed to examine students' applications of management concepts. Students who have learned concepts better and are more able to give examples of those concepts would be expected to be more likely to apply those concepts in their observations of classrooms, and, possibly, to be more likely to use the concepts in their own decision-making in classrooms. This, after all, is the goal of instruction in classroom management. Longer-term studies will be necessary to track these effects.

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Hypermedia in Teacher Education: Integrating Technology Across the Curriculum —The Marietta College Model

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The Marietta College mission is, "to provide students with an integrated, multidisciplinary approach to critical analysis, problem solving and the leadership skills required to translate what is learned into effective action ... to bridge between the world of thought and the world of action." In support of this mission the education department has developed the Marietta College Model for integrating hypermedia technology into teacher education undergraduate and graduate programs.

The Marietta College Model embodies five components: acceptance, understanding, application, evaluation, and design; introduced at the freshman level and integrated into all education courses throughout the undergraduate program, culminating at the graduate level. This article addresses the rationale for integrating hypermedia into teacher education courses, defines the components of the Marietta College Model, provides examples of activities, and discusses future programs.

Rationale

The underlying assumptions are: that computers and advanced technology enhance the teaching/learning processes; that providing relevant experiences with technology at the college level will promote the sound use of technology in the public schools; that hands-on experience with technology fosters the confidence needed to maintain and increase usage; and that integration reinforces usage in all subjects and with all grade levels.

Prior to college, students' experiences with computers and technology are typically limited to basic word processing and educational software they used while attending public school. Few have heard the terms hypermedia, CD-ROM, videodisc, and interactive video. They shy from investigating these media advancements due to lack of exposure, knowledge, and self-confidence in successfully manipulating the technology. If students exit the college learning environment without appropriate background experience in technology, they will have less time and inclination to interact with the technology once they become teachers.

Marietta College believes that technology empowers teachers. It provides them with the knowledge and ability to become more effective instructors and decision makers. To this end, the education department has developed an interactive hypermedia workstation that includes videodisc, CD-ROM, sound, graphics, and computer software used as either stand alone devices or orchestrated through IBM's LinkWay program. The Marietta College Model has integrated hypermedia technology into all professional education courses by developing and implementing the following integrated, sequential model.

Component I: Acceptance

Exposure is the greatest common denominator of acceptance and the first step in building competency levels. Without acceptance and familiarity, students will avoid exploring new technology. Students involved in the Marietta College Model accept hypermedia technology because they are gradually exposed to the medium in their classes.

The professors begin using the technology as an instructional tool in the lower level education courses of Principles of Education, Educational Psychology, and Introduction to Special Education, which are required courses. The usage at this level is limited to CD-ROM and videodisc either controlled by the computer or as stand alone technology. These experiences include viewing segments of video and CD-ROM discs to illustrate concepts presented during class. One example is showing segments of the movies, *Rain Man, My Left Foot, Children of a Lesser God*, and *Born on the Fourth of July*, to examine the areas of autism, cerebral palsy, hearing, and orthopedic handicaps. These movies provide a rich, visual context in which special education becomes more meaningful.

The first time videodisc is used in class, students begin their education about hypermedia technology. The function, uses, and format of CD-ROM and videodisc are explained to the students. Time is set aside in class to briefly describe a CD-ROM and videodisc player. Each course syllabus addresses the awareness level component. Students in these courses experience the quick access of information, learn to manipulate the players, and apply the information presented from the media. The videodiscs become an accepted instructional strategy, and the professors become the models for students. Paramount to student acceptance is witnessing the acceptance and enthusiasm of the faculty.

Component II: Understanding

The second component is introduced in same courses as the awareness component, as well as in the higher level methods courses. The goals of this component are to educate students about how hypermedia technology can be used to enhance their own education and for teaching children in the public schools. In Educational Psychology, students are taught to use CD-ROM for research purposes. In Introduction to Special Education, students are shown how hypermedia technology facilitates the education of special students. In methods courses, students explore CD-ROM and videodiscs directly applicable to their subject area. Upon completion of this component, students should have the necessary knowledge and understanding of hypermedia technology to begin applying it to teaching situations.

Component III: Application

Included in the teacher education program at Marietta College are three hundred hours of clinical and field experiences completed prior to the student teaching experience. The methods and upper level education courses encompass approximately two hundred of these hours. During these methods and upper level courses, students teach a significant number of hours in the public schools.

The goals of the application component are: to develop lessons incorporating CD-ROM and videodisc technology controlled by computer or on a stand alone basis; and to incorporate CD-ROM and videodisc technology in lessons based upon sound learning theory. The level of videodisc usage is determined by the requirements of the course and the expertise of the student. All students are required to develop and demonstrate lessons, and communicate how the usage enhances the teaching/learning process. Students in science methods develop lessons to enhance the inquiry process; students in learning disabilities classes develop lessons to modify content presentations for LD students, and students in reading classes develop literature presentations. The technology is used to make learning conceptual and context specific.

Component IV: Evaluation

The evaluation component demands a higher intellectual commitment for students. At this stage students are not only consumers and users of hypermedia technology, they must also evaluate commercial hypermedia, videodisc and CD-ROM discs, and computer software. The also evaluate their own and their classmates' lessons in relation to learning theory, presentation appeal, and design effectiveness. Students search the literature about hypermedia technology and present their findings in a paper. The goals of the evaluation component are to critically evaluate commercial programs, their own lessons, and current practices, and to make sound educational decisions based upon those evaluations. This component is presented during the latter part of the methods and upper level education courses.

Component V: Design

The design component focuses on masters' level students who are certified teachers. One of the core courses in the master of arts degree is Advanced Instructional Strategies. This course is designed to educate teachers about hypermedia technology and provide them the experience of designing or authoring a hypermedia application. The goals include all of those in the other components, as well as gaining expertise in developing and using hypermedia technology, becoming advocates of sound technological practice in the public schools, and demonstrating leadership skills in developing technologically progressive schools.

Most masters' students in the Marietta College program come from a fifty mile radius and represent approximately 10 school districts. When graduate students design applications and demonstrate them in their school, they are not only impacting their students but also other teachers.

Future Programs

The public schools in the geographic region surrounding Marietta College are enthusiastic about this technology, but feel uncomfortable with it. When Marietta College student teachers take hypermedia into area classrooms, they serve as a conduit to introduce hypermedia to the public schools. The education department reinforces the use of hypermedia technology by sponsoring workshops and programs for public school personnel.

One such program scheduled for Fall, 1991 is The Visiting Classroom. This program will bring public school teachers and students on campus for a one week period. The college students will be responsible for planning, organizing, and teaching the public school children while the classroom teacher pairs with a faculty member to learn hypermedia technology. As the number of educators who hear about hypermedia grows, so do the requests for hypermedia demonstrations. Interest, knowledge, and enthusiasm about hypermedia technology is expanding among public school teachers.

Perils and Pitfalls

The first and greatest problem experienced in implementing the Marietta College Model has been scheduling computer lab time. While several labs exist on campus, so do courses that demand lab time. This is particularly evident in the masters' course. Since the students are teachers and work during the day, their lab times and class meeting times must be scheduled in the evenings and on weekends. Designing lessons and applications often require larger blocks of time than can be scheduled. This causes some frustration among students.

The second problem is that of equipment, which is a mixed blessing. After students design applications and lessons, they want to demonstrate and use the lessons in their schools. Some schools have not yet procured the equipment needed. The students often ask the college to lend our equipment, which is not abundant. The college tries to accommodate the students and provide demonstrations for schools in order to encourage equipment purchase and use, but the college's resources for such activities are limited. Graduate students are encouraged to write grants and investigate funding sources to establish a hypermedia program in their school. Admittedly, progress is slow but steady.

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Impact of Interactive Videodisc Technology on Preservice Teachers' Ability to Analyze Motor Performance

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Motor performance represents the content of physical education and sport. This suggests that physical education teachers and coaches possess the ability to observe, analyze, and evaluate motor performance while determining appropriate feedback and remediation.

To accurately assess motor performance, the observer must be able to determine effectiveness of performance in a brief moment in time. Videotape allows the dynamics of human movement to be captured in a permanent product, thus providing the opportunity to more accurately study specific elements represented in an efficient motor performance.

Interactive videodisc technology provides additional advantages to analysis of sport skills by allowing knowledge of content and visual discrimination skills to be developed simultaneously. Videodisc allows quick and easy access to human performance, viewing at various speeds for more effective analysis, feedback relative to understanding the content, and application of content knowledge to correct analysis of motor performance. Theoretically, interactive videodisc should provide several advantages to the traditional method of teaching skill analysis. The purpose of this study was to compare the effectiveness of teaching skill analysis of long jump using the traditional teacher-directed lecture method and interactive videodisc technology.

Methodology

Subjects

Subjects were 19 male and female preservice physical education teachers in a required sophomore skill analysis course. Subjects were pretested on knowledge of content and ability to analyze skill performance of long jump, then placed in rank order based on their pre-test scores. Matched pairs from this ranked list were randomly placed in one of two treatment groups.

Design and Treatment

A quasi-experimental pre-test/post-test control group design with matching (Borg & Gall, 1983) was utilized for this study. Two treatments were used as the independent variables; ten subjects received teacher-directed instruction (TDI) and nine subjects received interactive videodisc instruction (IVD). IVD instruction used the Self-instructing Module for Skill Analysis of Long Jump developed by Tannehill, O'Sullivan, Stroot, and Chou (1989). Teacher-directed instruction used the same instructional design and format as the experimental treatment relative to sequence, prototype, graphics, video, and terminology.

Procedures

Teacher-directed instruction took place during two 50-minute class sessions for a total of 1 hour and 40 minutes of instruction. Interactive videodisc instruction was conducted in a specially designed interactive videodisc laboratory. Time used for interactive videodisc instruction and interaction with the materials ranged from 35 minutes to one hour and twelve minutes with an average of 53 minutes.

Data Collection

Scores achieved on two post-test measures represented the dependent variables. One post-test measure was an exact replication of the pre-test used to measure entry knowledge of content and ability to analyze long jump skills. A second post-test measure assessed ability to critically analyze a "live" performance of the long jump in a realistic setting.

Data Analysis and Results

Analysis of variance (ANOVA) results for the pre-test/post-test scores revealed no significant differences between groups. Analysis of variance (ANOVA) on response from the content knowledge and critical analysis questions of the post-test also revealed no significant differences between groups. Analysis of frequency data to identify trends revealed both groups performing equally well in some cases and equally poorly in others. Results of a t-test conducted on the "live" post-test scores revealed no significant differences between groups.

Discussion

Findings from this study indicate that the interactive videodisc training module was as effective as a teacher-directed instructional approach. Neither approach was particularly effective for teaching content knowledge or critical analysis of the long jump. One possible explanation for this finding might be the technical complexity of content. Expecting learners to master in less than two hours an analytic skill which takes many track and field coaches months and even years to master seems unrealistic. Long jump is a complex event which is composed of two completely different skills, sprinting and jumping. Perhaps a more effective method would be to teach content and analysis of sprinting and jumping separately, combining them into the more advanced skill of long jumping only after initial mastery is achieved. Walkley & Kelly (1989) reported similar findings relative to differences between teacher-direct instruction and interactive videodisc instruction with skills analysis training. Due to the "time and teacher dependency limitation" (p. 283) of teacher-directed instruction, they were encouraged by future prospects for interactive videodisc instruction in this content area. Despite limitations identified with this package, use of interactive videodisc instruction has possibilities for use in skill analysis training of preservice teachers which can only be realized through continued exploration of this technology.

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Instructional Contrasts in Elementary Science Teaching

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In order to make the preparation of elementary science teachers more responsive to current needs and, at the same time, incorporate findings of the most recent research, a study was undertaken at Vanderbilt University in the Spring of 1989. While the purposes of the study were multifaceted, the study was undertaken in an effort to 1) identify those teaching competencies that distinguished teachers with a high degree of success, or "expert" science teachers from pre-service or beginning teachers, or "novice" teachers and 2) devise ways of teaching these competencies to pre-service teachers in a way consistent with the latest learning theories.

New ways of preparing teachers can be based on the idea that, contrary to Piagetian theory, expertise is not so much the result of developing capacities for problem solving or incremental stages of development as it is the result of a superior knowledge base on the part of the "expert" (Bransford, Sherwood, Vye, and Rieser, 1986). The mere acquisition of knowledge, however, is not enough—it must be organized in such a way that a person can access it when necessary, and it must be "conditionalized knowledge." Bransford et al (1986) explain the importance of acquiring information about the "conditions and constraints" of the use to which knowledge is to be put (p.1081).

According to this view, the expert teacher, then, is one who has a solid base of knowledge that is specifically related to the classroom environment and to the problems ordinarily encountered in the classroom. In addition, this knowledge base has been organized in such a way as to permit the teacher to access it easily and to transfer the relevant knowledge to the problem solving process.

The study at Vanderbilt first focussed on the identification of these competencies and then on methods for teaching them to the pre-service teachers. The competencies identified were based on what research in science teaching has identified as teaching practices or strategies known to produce gains in achievement, on what the profession believes is associated with effective teaching practices, and on what Vanderbilt University believes to be important. It was thought possible to increase the ability of the pre-service teachers to transfer knowledge gained in the classroom by exposing them, via video technology, to the environment in which the competencies under study would be used. In addition, by showing them actual classroom situations and lessons which demonstrate various problem solving techniques, or competencies, it was thought possible to ensure that this newly acquired information is structured in memory so as to facilitate easy access and enable pre-service teachers to see the relevance of the competencies studied.

With this in mind, a series of videodiscs with HyperCard stacks are in various stages of development. The first, "Instructional Contrasts in Science Teaching," presents a graduate student teaching a science lesson about evaporation using teaching practices commonly observed in many elementary science classrooms. The same teacher also teaches a guided discovery lesson about ice cubes using "hands-on" techniques advocated by the research literature and by experts in science teaching. In the first lesson, the children listened to the teacher as she presented information, responded to her questions, watched a demonstration, and engaged in an independent activity involving cutting and pasting on a worksheet. In the second lesson, after a problem has been set up by the teacher about keeping ice cubes longer, the children worked in groups, gathered data about how various types of cups keep ice longer. At the end of the lesson, the data gathered by each group was summarized and the concept of an insulator was invented by the teacher. A HyperCard stack was written which showed the contrast between each of the teaching episodes in terms of some of the competencies identified in the initial phases of the study.

For instance, one of the competencies identified in the review of the literature was the use of pre-instructional strategies. Boulanger, in a meta-analysis conducted in 1981, showed that, of six instructional clusters identified from fifty-one studies, the use of pre-instructional strategies produced the most significant gains in terms of student conceptual gains. Other studies have been less conclusive (Lott, 1983). It seems fair to say, however, that an effective teacher with an expertise in teaching might be found using some type of pre-instructional strategy as part of the lesson (Hartley and Davies, 1976).

Consequently, one section of the HyperCard stack deals with introducing the lesson. Students are given a statement about the purpose of introducing the lesson. Then they are presented with a "button" which allows them to see clips from the videodisc that show how the teacher introduced each of the lessons. They are then asked the question, "In which lesson did the teacher focus attention on what was to be learned or inform students of the objective of the lesson?" In this way, students are encouraged to draw comparisons and contrast the two different methods employed. Next, they are introduced to the term, "set induction." The text on the screen says, "A question posed by the teacher to spark the interest of the students that can be answered later in the lesson is called set induction." Again they are directed to a video clip showing that competency in use. They are asked, "How was the question posed by the teacher answered in the lesson?" At the end of this lesson, students are asked to consider, "In which lesson do you feel that students were adequately prepared for what was to be learned?" The stack proceeds through six more competencies that have been identified by Vanderbilt project researchers.

The videodisc is currently being used in another phase of the project, so it has not been possible to use it in the actual methods courses as yet. Preliminary testing seems to indicate that the use of video technology in conjunction with HyperCard presentations may be a very powerful method for helping students develop a knowledge base that

- is organized in such a way as to facilitate retrieval in the field and,
- contains enough information about the specific domain in which it is to be used (and the conditions affecting its use) as to make it more closely approximate the knowledge bases of the "experts."

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Getting Started with the Visual Almanac

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Nothing competes with lunch.
paraphrased from **The Visual Almanac Companion**

Introduction

As I write this article, I am listening to a cacophony of sounds coming from my CD player. At first a loud series of pops (I nearly blew out my speakers), but then I heard what I simply must call some really 'neat' sounds. On my right speaker, someone is talking about the solar system; on my left speaker are sounds straight from the Saturday morning cartoons. Unfortunately, I am more familiar with the sounds on the left than on the right. I am intrigued. I want to hear more. So for the next 45 minutes, I sit enthralled by what I can only describe as a collection of various sounds, music and noises— with some recognizable talking thrown in for good measure. It's almost like the ultimate minimalist compact disc. This is the Visual Almanac?

I pick up the book that comes along with the Visual Almanac. It's unlike any manual I've ever seen before. For one thing, its actually contains stories about real people who are using the videodisc. It's funny (the manual calls itself 'playful'—I'll overlook that) and it actually tells me and shows me what to do. There are real pictures and diagrams that show me what cable goes in what place. It even tells me what to do if I don't have a computer. And it's a good read. As an educator I like that.

Finally, I get around to putting the videodisc into the videodisc player. I see some introductory material. I see some credits and then I see the earth going around the sun. I think, "This is not bad." The videodisc keeps playing. I see more space pictures and then I see some children playing in the playground. A roller coaster, some other amusement park rides and some guy jumping in a tub of starch are all on the videodisc. This is great. It's like all the stuff my public school teachers were talking about and couldn't really show me. I begin to wonder—What if?

What if?

Hannafin & Peck (1988) have called interactive video perhaps the most promising interactive technology. Anadam and Kelly (1981) have noted that interactive video "changes the student from passive observer to active participant." Dockterman (1990) stresses that we need to "make the technology truly accessible to the teachers." (He also suggests that we steal computers from the lab and put them in the department office, but that's another story!) Does the Visual Almanac meet these criteria? You be the judge.

The Visual Almanac is available from Optical Data for $100.00. Not bad considering you get the videodisc, the Visual Almanac Companion, a CD-ROM disc with 28 megabytes of software (mostly programs created by Apple, but also some 'compositions' created by the first users of the Visual Almanac), three floppies with HyperCard and a few other stacks, and a cable that will allow you to connect your videodisc player to a computer.

First suggestion: Don't mess with the computer—yet! Take out the Visual Almanac Companion. Turn to page 57 and read Ham and Cheese on Rye, with Juice and the Visual Almanac. Then turn to page 63 and read Debut at Berkley High. Finally, turn to the beginning and start reading. Set aside an afternoon. Prepare to say "What if?".

Second suggestion: Put the videodisc in your videodisc player. Turn it on. Turn on your monitor. Press the play button on the front of your machine. Sit back. You'll see some pretty interesting video. Some still pictures will flash by too fast for you to really see them, but that's ok for now. If you're a science teacher, watch the science info carefully but then watch the 'Day in the Life of' series on side 2 carefully too. If you're a history teacher, don't just skip over the science section. Learn something. And then just for fun, watch the fruit going bad in reverse.

Third suggestion: Write to Apple and tell them that most of us don't have CD-ROM players. There is a lot of great software on the CD-ROM which comes with the Visual Almanac but if you don't have access to a CD-ROM player, you can't use it! The Visual Almanac Companion talks about all of these great stacks that most educators can't use without going 'off-base' to an Apple dealer or another school that fortunately has a CD-ROM player. If at all possible, beg or borrow one (our computer store wasn't using theirs at night) so you can put some of the software from the CD onto your hard disk or floppies. This will allow you to utilize the excellent programs that come with the Visual Almanac and to get an idea of the many varied styles of presentations that can be created using the videodisc.

If you don't have a program like the Voyager Videostack (which will allow you to control the videodisc player from your computer), make sure to get the 'Workspace Master' off of the CD that comes with the Visual Almanac. This will provide a fairly painless way for non-programmers to create their own compositions. In addition, it's fairly easy to use HyperCard to create you own stacks which, when combined with the Voyager Videostack, will allow you to make interactive programs utilizing both the computer and the videodisc player. It's not as hard as you might think. The key, however, is to remember that programming is not absolutely necessary. Use the remote that came with your videodisc player, find the info you want to show, and write down the frame/chapter numbers for what you want to show. After all, it's your toy first!

What if? (part II)

If you've got access to a Macintosh, you've probably looked at HyperCard. If your students have access to the Mac, you can bet they've looked at HyperCard. Be brave—let your students create their own stacks. Furthermore, show them the Visual Almanac. Teach them, using whatever method you've decided to use, how to control the videodisc player. Then leave them alone. Be close by to answer questions, but don't assign any specific projects. If Joe wants to find all the pictures of monkeys and Mary wants to look for information about famous women, let them go for it! If you have students who have a hard time getting started, ask them some "What if"'s: What if that fruit were left out on a table? What if the sun was the size of a pumpkin? Add a couple of "How did"'s: How did your parent's clothing differ from your own? How did people communicate with one another? And then ask "WHY?"

Hannafin & Peck (1988) clearly state that "(t)here are applications for which it (interactive video) is the only logical solution, others for which it is one of several good solutions, and still others where it is simply unnecessary". (p. 362) No medium, no matter how strong, will reach every learner or is appropriate to every task. If, however, we can help our students and our colleagues to ask the whys and the what ifs and to see that learning is a process of involvement, then perhaps we as educators can learn ourselves. The Visual Almanac is no more a panacea than are computers or any new technologies which may arise. It is simply one more tool for us to use.

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Incorporating a Computer-Based Visual Learning Activity/ Experiment in an Audiovisual Methods Survey Course

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Introduction

It is crucial that we understand how individuals interac^ and react with computer based instruction. "Technologies do not mediate learning. Rather knowledge is mediated by the thought processes engendered by technologies. So we must look for the instructional designs that result in the most productive thought processes, which in turn result in the greatest learning." (Jonasson, 1988, p. xv)

Undergraduates read about research and about systematic instructional design but usually neither touches them directly or reinforces class concepts. Thus, the impetus to provide a computer-based visual learning activity is not only to obtain research data which may be of use in designing the visual components of computer based instruction, but also to involve students preparing to be teachers in the research process and to make both research and instructional design more real and immediate for them by linking it with course content.

Clemson University's Department of Elementary and Secondary Education offers a standard survey audiovisual methods course for upper level teacher trainees. Early in the course a very important foundation is laid for later materials development and proper utilization of visual material when students study research on perception, visual learning and visual design as well as the role of individual differences such as cognitive style (Heinich, Molenda, & Russell, 1989).

In order to increase student involvement in this part of the course I have devised a combination learning activity and experiment. The purpose of the activity is threefold: awareness of the visual nature of learning by computer; that is, the importance of such elements of screen design as visual cues, sequencing, and information load; awareness of individual differences in the nature of perception and cognitive processing; and understanding the importance of research findings in determining the systematic selection and design of materials.

Nature of the Experiment/Learning Activity

The present activity is based on an earlier study by the instructor which examined performance on a map-learning task in relation to cognitive style (field dependence-independence). Based on evidence that field independent learners are more analytical and deal more successfully with complex visual information than field dependent ones, the previous study involved designing map presentations that attempted to match the learning characteristics of each orientation. Results showed that field independent students recalled significantly more map information under all conditions.

As learners, individuals who have been determined to be more field independent are said to be better able to organize and structure information (Witkin, Moore, Goodenough & Cox, 1977). As such they have been shown to have more success at learning visual-spatial information in the form of maps than field dependents (Reardon & Moore, 1988; Stasz & Thorndike, 1980). These students should be successful with either the learner controlled visual treatment or the intact map treatment, both of which allow them to choose strategies. Those who are more field dependent tend to be more passive learners and should be more successful with the external control.

Description of Learning Activity/Experiment

The exploratory experiment described here consists of a visual learning task which was completed by 17 students in a survey Audiovisual Methods course. Hard copies of the map information were employed limiting possibilities of presentation manipulation. One of the goals of the present study was to convert the task to HyperCard format to allow more flexibility in format and thus learning strategy selection.

A HyperCard stack consisting of imaginary maps was developed for the experiment. Maps were selected for the project as a visual learning task because they are examples of familiar, complex, spatially oriented material which most teachers and learners will encounter in instructional situations. Instructional design for map learning has been investigated by a number of researchers (Kulhavy, Schwartz, & Shaha, 1982; MacEachren, 1982; Shaha, 1982; Shimron, 1978; Stasz & Thorndike, 1980). Since the maps are imaginary, students could not have had prior knowledge of the information.

Research questions for the study were:

1) Which treatment leads to greater immediate recall?
2) Which treatment leads to greater delayed recall?
3) Which cognitive style orientation exhibits greater recall?
4) Is there an interaction between condition and cognitive style orientation?
5) How does time on task relate to post-test achievement and to cognitive style?
6) How are sequencing choices (visual learning strategies) related to achievement and to cognitive style?

Seventeen students in an audiovisual survey class (12 undergraduate and 5 graduate) took the Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971), to measure their level of FD-I (field dependence-independence) and individually completed a computer-based map learning task. There were three conditions of the task: the first, designated as learner control, showed the addition of layers of information through the three views and then allowed students to zoom in on each of the four quadrants. Students could go backward or forward through the frames with no time limit. The second condition used the same stack or set of frames but was prerecorded with the MediaTracks (ScreenRecorder) program into a presentation lasting slightly over three minutes. Here, although the computer controlled the sequence, the students could replay the tape as many times as they wished, so that they did have some control over time. The final condition was simply the unmodified map, which the student could study as long as desired. (Mean times on map study were 327 seconds for the first condition, 261 seconds for treatment 2, and 152 seconds for treatment 3

To prepare the presentations the map images were scanned and entered into HyperCard stacks, and buttons to link the cards and direct the learner, along with text directions and cues were added. For conditions 1 and 3, the student worked through the stack in normal Macintosh style, clicking on appropriate areas with a mouse. For condition 2, student input was limited to clicking on the button to play the tape.

Treatments were randomly assigned to times; when a student signed up for a particular time, he or she also was assigned a treatment. Students worked individually on a Macintosh SE set up in a media lab. They were given basic instructions on how to use the mouse to move through the presentation and were asked about their proficiency with the computer and their familiarity with the HyperCard program. No student was more than somewhat proficient with the computer; none were more than slightly familiar with HyperCard.

For treatments 1 and 3, the student recorded a tape of the path through the material. The tapes could be saved, replayed as desired and analyzed. Using the MediaTracks editor, a time was recorded for each frame or card change and for overall map study time. With treatment 2, time on task was calculated by multiplying the number of times the student reported watching the tape, since the tape length was known. Overall times ranged from 75 seconds to 697 seconds, or from 1 minute 15 seconds to over 11 minutes. Following the map study exercise, students took a paper and pencil test consisting of visual identification and a verbal multiple choice sections. (Previously established reliability for the test was .76. Reliability was not calculated for this sample.)

Results

At first examination, means appeared substantially higher for treatment 1, the learner control condition (post-test means were 17.2, 15 and 13.2 out of a possible 20 for treatments 1, 2 and 3 respectively). When only treatments 1 and 3 were compared in a one-way ANOVA (treatments 1 and 2, consisting of the same map frames could be considered very similar except for the greater learner control over the first), differences seemed to be significant. On further inspection, GEFT scores also seemed to differ in the same direction. In fact, GEFT scores correlated fairly highly with post-test scores ($r^2 = .81$). Since GEFT is known to be related to spatial ability, and thus to map-learning ability, there was the possibility that an uneven distribution of FD-I individuals was influencing the results. An analysis of co-variance showed that this was indeed the case. Most of the individuals who received treatment 1 were high scorers on the GEFT and those in treatment 3 were low-scorers. In the previous study FD-I was significantly related to map learning performance. For this small sample it approached significance.

There was also a low positive correlation between scores on the GEFT and time on task ($r^2 = .48$) and between test scores and time on task ($r^2 = .47$). Some researchers have looked at the efficiency index, reasoning that the highest score one can achieve in the shortest time is preferable. Efficiency scores show treatment 3 to be just slightly more efficient; however, a person who scored 11 out of 20 was highest on efficiency, spending only 75 seconds studying the map. One might question whether that sort of efficiency is really very desirable. Finally, to measure delayed recall, the class was given the same test again three weeks after taking it the first time. The average drop in scores was about three items for each treatment, but several students maintained their scores and one student increased from 19 to a perfect 20.

There were several problems encountered with the experiment, primarily related to the small sample size which meant that some research questions, such as possible interaction between cognitive style and treatment, could not be addressed. One student's tape could not be used as he mistook the instructions to "look at three views" to mean that he should only study the first frame which showed three county boundaries. Another student who was assigned the intact map condition accidently discovered the embedded zoom feature when he clicked on the right unmarked area. (It should have been removed and was, promptly, at that point.) These occurrences were discovered from studying the tapes and the two students' data were not used. One other student wandered a bit although the stack was carefully planned to limit undesired exploration. The recorded sequence for each participant offered extra possibilities for analysis and follow-up.

Overall, students did appear to do better on a test of immediate recall after viewing a condition where they saw a building up of information; but the differences were not statistically significant. They also spent more time with this condition. Although some would ascribe the longer times to lack of efficiency, time on task has long been a barometer of learning—more time produces more learning. On the other hand, studies of computer learning have often shown an increase in efficiency. Past studies have shown a relationship between facility with map learning and field independence. Apparently part of what is measured by the GEFT is spatial ability.

Impact as a Class Activity

As previously stated this was a first attempt at making research a part of the course and it clearly did not involve students adequately in the planning process; yet it piqued their interest and all willingly took part. We had covered rather carefully visual design, information load and complexity and characteristics of research on media. Students were not given very specific information about the experiment at the beginning of the project so as not to influence results. Afterwards we discussed characteristics of field dependence and independence, the GEFT and its relationship to spatial ability and cognitive restructuring. There was a simple explanation of the statistics used and their meaning. Discussion also involved such questions as why field dependent learners might spend a shorter time on task. We concluded that it is possibly evidence of a difficulty with focusing or organizing scanning behavior (which other research has reported; see Fleming, 1984). Other interesting results were noted: the most field independent person spent an inordinate amount of time on the task, but, as an older student who has recently returned to school, confessed to a high level of anxiety over the whole process. The use of the zooming-in technique was not as pronounced as expected; some students skipped it entirely and the others did not seem to rely on it heavily.

Future Directions

Although there were few significant differences to be seen with the small sample employed, there were a few tantalizing hints of fruitful future directions for this type of project. For example, one student's score rose from 19 to 20 on the delayed recall test, a perfect score. Examination of this student's tape reveals a very evident strategy, a careful tracing of map boundaries and other details using the pointer arrow. What if future participants were specifically directed to use this particular strategy? What if tapes of the strategies judged most and least effective were presented as alternatives in a future experiment; who would choose which and would there be a measurable difference in achievement? It is exciting to think about the possibilities. It is not necessary to start from scratch in developing projects; for example, software such as the HyperCard-based Active Eye (Mills, M., & Schiff, W., 1989) includes perceptual experiments which might be applied to a media course. Efforts to explore visual learning with my classes will continue to be computer based; for its interactive nature, tools for manipulation and flexibility offer fertile ground for research. I believe strongly that students who participate in research are more likely to be objective, concerned teachers, not afraid to question the design and effectiveness of the materials and of the technology which they employ in the classroom.

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Improving Remedial Reading Instruction Using Video-Based Case Analysis

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Theorists and researchers who are examining factors contributing to effective teacher education programs provide compelling reasons for reforming methodology courses and field experiences if our goal for these programs is to prepare teachers for solving problems in complex and problem-laden contexts (Berliner, 1985; Clandinin & Connelly, 1986). A decade of observational and experimental literature in which expert teachers' actions and thoughts have been examined reaffirms our long standing belief that the practice of teaching is a complex cognitive skill and that teaching, occurring in relatively ill-defined environments, requires not only knowledge about what to do but the ability to know when and how to use this information when confronted with problems and unexpected situations (Clark, 1988; Leinhardt & Greeno, 1986). Yet, methods courses, microteaching, and other preteaching experiences may fail to equip teachers with problem solving strategies because they do not reflect the "intrinsic uncertainty of teaching" (Clark, p. 10) and may present a simplistic or unrepresentative view of teaching (Ball & Feiman-Nemser, 1986; Clark, 1988).

Although a major goal of teacher education programs is to prepare teachers to apply information learned during college classes and field placements to problems encountered in real classrooms, college courses often develop factual knowledge of various methods and activities without developing problem solving strategies that are needed for the appropriate application of these methods. Meaningful use of information "learned" in college classes may be inhibited because prospective teachers don't understand how to use this information to solve problems or they don't understand conditions requiring the use of information. They may not make the necessary transition from acquiring factual knowledge to developing procedural or use-oriented knowledge (Bransford & Vye, 1989).

Description

At Vanderbilt University, we are currently involved in a project using technology as an alternative to a lecture approach to education. This project was partially funded by a Sears-Roebuck Foundation Grant designated for Instruction for the Improvement of Undergraduate Teaching and Learning (Risko, 1988). Influenced by earlier projects at our technology center (e.g., Barron, Bransford, Kulewicz, & Hasselbring, 1989; Bransford, Sherwood, & Hasselbring, 1988; Risko & Kinzer, 1986), we are involving our students in shared-learning contexts for the analysis of problems confronting teachers, as illustrated in video-based case examples. We believe these cases can help future teachers recognize similarity between information learned in college classes and information required for successful teaching in real classrooms (Bransford, Franks, Vye, & Sherwood, 1989). Our previous work (CTG at Vanderbilt, 1990; McLarty, Goodman, Risko, Kinzer, Vye, Rowe, & Carson, 1990) with instruction that is anchored in videodisc-based, problem-solving environments suggests ways to think differently about the process of building teachers' useable knowledge.

To improve the learning of future teachers at our university, we targeted an undergraduate course that is taught on a regular basis. This course, Remedial Reading and Practicum, is a required course for elementary and special education majors. It is offered twice a year to be taken during the students' junior or senior year. For the first eight weeks, regular class sessions are held on campus. For the remaining six weeks, each student is assigned to a practicum setting and is responsible for planning and implementing reading instruction for a low achieving student.

Problems Observed in Target Course Prior to Revision

Even though students have completed one reading course and a reading-related course with an accompanying practicum prior to enrolling in the remedial reading course, students come to this course with "textbook" definitions of the reading process and restricted notions about the complex demands of providing reading instruction for the disabled reader. Their understanding of remedial readers tends to be narrow, usually related to "have not" characteristics (e.g., limited mental ability, deprived family life, deficient skill development) which further restricts their understanding of low achieving students' capabilities and the multiple factors that might interact to produce disabled readers. They have naive understandings of diagnostic instruction, assuming that a test-teach cycle will produce "quick fixes" for complex problems.

Misconceptions held by our undergraduate, future teachers seem to mirror the actions of practicing teachers in regular classrooms and resource rooms who are unable to provide adequate reading instruction for children. For example, extensive observations of instruction suggest that teachers confuse instruction with assessment (Durkin, 1978-1979), and that both good and poor readers are receiving fragmented and incoherent instruction (Allington, Boxer, & Broikou, 1987; Allington, Stuetzel, Shake, & Lamarche, 1986; Bean & Eichelberger, 1985).

Prior to our plan for revision, much of the remedial reading class was devoted to helping students understand that instruction is affected by multiple factors (e.g., teachers' beliefs, teacher knowledge of assessment and instructional strategies, students' diverse learning needs). Prototypic, written case studies were examined to illustrate the conduct of specific assessment and instructional strategies and problems that students may encounter. Students seemed to leave the course with more information about the range of factors affecting the reading process and how to evaluate the appropriateness of instructional strategies. Yet, these students seemed limited in their use of alternate strategies.

Revising Process

We developed three cases that are recorded on videodisc and are enhanced by HyperCard and microcomputer technology. Our goal for these cases was to develop rich contexts within which factors related to reading problems could be studied from multiple perspectives. Instead of giving students information about how problems were resolved in a case study, students are personally involved in exploring relationships, identifying questions, and finding answers to questions. The videodisc approach that we are using allows for cross-referencing of information across cases.

In order to prepare these videodiscs, entire lessons conducted by each teacher were videotaped during six to eight weeks of instruction. Hours of videotaped segments were edited and condensed for the production of three thirty minute master tapes which were then pressed onto three videodiscs. Each case contains various forms of naturally occurring classroom events (e.g., teacher-student interaction, parent-teacher interviews, student participation in guided reading lessons) demonstrating factors that contribute to the complexity (and irregularity) of reading disabilities.

In addition to our videodiscs, HyperCard technology was also developed to enhance the effectiveness of instruction, both for whole class and independent student activity, by encouraging access to multiple sources of information for a more elaborative, in-depth study of each case. The opening menu for each hypermedia stack corresponding to each case indicates that the viewer is the diagnostic problem solver and can choose multiple sources of information (e.g., oral reading data, instructional scenes) to learn about the selected case.

Our HyperCard stack serves several additional purposes. An initial card in the stack indicates the wide range of factors (e.g., instructional context, background knowledge, text characteristics, knowledge/use of language cueing systems, beliefs/attitudes, knowledge/use of strategies, and knowledge/use of comprehension cues) that can be examined for analyzing possible factors contributing to the student's reading difficulty. Our hypermedia stacks were assembled

(1) to provide access to testing information (e.g., graphs of scores),
(2) to provide video scenes of students' performance on both product-and process-oriented measures (e.g., actual observations of "body language" as well as oral

reading during individualized reading tests),
(3) to include relevant text materials for clarifying concepts, and
(4) to access video scenes in which instructional methods are contrasted.

Our use of HyperCard also facilitates viewing a single case from multiple perspectives. For example, if a case is viewed for the purpose of determining a teacher's decision leading to management and grouping arrangements, it can also, through another HyperCard stack, be viewed for the purposes of analyzing a teacher's questioning strategies, and again for determining the teacher's strategies for enhancing students' vocabulary development, and so on. Because the cases are on videodisc, appropriate scenes can be easily and quickly accessed. Returning to a case in this manner is difficult in videotape applications or when there is no guiding "script" which is available through HyperCard.

Rationale for Our Case Design

There are at least two specific reasons why we believe our cases can have a positive impact on preparing teachers to think flexibly and to solve disparate problems in the classroom. First, our approach to the analysis of cases, similar to procedures advocated by Rasinski (1989) and Eldridge (1990), is process-oriented. Too often cases provide both the problem and the solution. The provision of a specific, "correct" solution, however, prevents students from taking an active role in making decisions about how information should be framed and about how problems could be solved. This violates learning principles suggesting that students' active generation of solutions is most effective in promoting learning, including learning in college classes. Second, we believe that the use of technology to combine visual information with text represents an important advantage for video-based instruction over written case studies (see Bransford, Kinzer, Risko, Rowe, & Vye, 1989 for a more detailed discussion). It is possible and probable that traditional written cases are narrow in the content they present, not providing rich information about complex instructional contexts. While written case studies can provide rich descriptions, these descriptions are translations of what another author viewed. Conversely, video presentations provide the authentic classroom events, allowing each viewer to develop a personal description and interpretation. Video presentations can capture linguistic expressions plus visual and auditory information such as facial expressions of both the teacher and students, the environmental context for the lessons, inflections of voice, gestures of students. There is much to notice within the presentation. Increasing opportunities for noticing can increase the possibility of finding relevant information that leads to problem identification and problem solving.

Discussion

We do not view our video-based case analysis as a stand-alone procedure for enhancing teacher education. Instead, we believe that its potential benefits for preparing teachers may be influenced by a number of factors that we know are important for effective instruction. These factors include the importance of acknowledging and making use of students' background knowledge and previous experiences during class discussions (Anderson & Pearson, 1984), the benefit of cooperative learning when examining cases (Slavin, 1983), the facilitative effect of problem generation (Bransford, Franks, Vye, & Sherwood, 1989), the importance of teachers and peers mediating or coaching learning experiences (Bransford & Vye, 1989), and so on.

Based on what is known about effective instruction, our video cases were developed to provide opportunities for a professor and college students to work together in shared contexts. The use of our cases can encourage students to view information from their own perspective, to find information for exploring and framing problems, and to experience changes in their learning as they are introduced to new ideas from the professor, from the texts, and from their peers. We believe these cases can be used to create environments for analyzing the complexity of authentic classroom problems and for using information flexibly to generate solutions that are workable within specific situational contexts.

We are presently conducting a pilot study of our video case-based instruction. Preliminary observation tells us students' comments are more rich and elaborative compared to the target class. Additionally, students are integrating known facts into problem solving cases. Our goal is to document both the implementation as well as the learning that takes place through our case-based methodology.

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Use of Electronic Media in Competency-Based Student Teacher Supervision

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One way to increase the "pass rate" of new teachers on teacher competency evaluations is to conduct competency-based assessments while students are participating in college student teaching experiences. Videotaping students and student teachers for purposes of student self-assessment and assessment by supervisors is an effective strategy for achieving this goal (Koorland, Tuckman, Wallat, Long, Thomson, and Silverman, 1985).

The concern for teacher quality and the rapid growth of technical expertise in the field of teacher evaluation have made it possible to implement programs which evaluate observable teacher behaviors and make competency judgements. Two examples of appraisal systems of this type are the Georgia Teacher Performance Appraisal Instruments (TPAI) and the Florida Performance Measurement System (FPMS). Each of these appraisal systems uses generally agreed upon language which clearly describes observable teacher behaviors. Including this language into syllabi, outlines, lectures, and presentations in methods courses, with references to the research which used this language, can result in the preparation of beginning teachers who are better informed about both the evaluation process and the standard of performance required in public school systems.

Recent research in the area of teacher evaluation supports the claim that education majors should learn to systematically observe, recognize, and practice effective teaching behaviors prior to their student teaching experience. One conclusion reached in a study of the success rate of beginning teachers attempting to complete the Georgia TPAI was that beginning teachers assessed with the TPAI during student teaching had a higher success rate than those without this experience (Tanner and Ebers, 1985).

A pilot evaluation of the PRE-ED Program (Performance Related Experiences for Educator Development) was conducted at Florida State University which included a number of innovative practices. Student teachers videotaped themselves as they taught in their host classrooms and then mailed the videotapes to a faculty supervisory team on the Florida State University campus. Tapes of these student teachers were systematically evaluated by the supervisory team using the Florida Performance Measurement System (FPMS). After viewing the tapes the supervisory team initiated a conference call to the student teachers and their cooperating teachers. Feedback on effective and ineffective teaching behaviors was then provided. After videotaping sample lessons they taught and using the FPMS assessment instrument, student teachers participating in the PRE-ED program performed in a comparable if not superior manner to those student teachers receiving conventional supervision in a similar setting (Koorland, et al., 1985)

A study conducted at Elon College examined the reactions of 27 preservice secondary education students to the use of videotape as an assessment tool to assist them in developing effective teaching behaviors as defined by the North Carolina Teacher Performance Appraisal Instrument (TPAI).

Twenty-six senior education majors at Elon College were enrolled in Methods and Materials of High School Teaching during a fall semester. During the course of the semester each student was observed formally by a content specialist from his or her field and was videotaped while teaching a sample lesson. Next each student viewed the videotape and rated the effectiveness of his or her teaching on the college teacher assessment instrument which was modeled after the North Carolina Teacher Performance Appraisal Instrument (Elon College, 1987). The student then compared the result of their self-assessment with the content specialist's formal observation.

The following disciplinary areas were represented:

Code	*Discipline*	*Number*
He	Health	1
E	English	2
Hs	History	6
M	Mathematics	6
PE	Physical Education	11

At the end of the semester students were asked to "Briefly, compare and contrast the effectiveness of
1) superior feedback and
2) self criticism using videotapes following an episode of practice teaching."

As might be expected, videotaping the students provoked mixed reactions, some of which were negative. However it should be noted that positive reactions outnumbered negative reactions by a ratio of three to one. Excerpts that reflect their feelings, keyed to each discipline, are as follows:

Negative responses

He It was nerve-wracking.
M I didn't like seeing myself on TV.
M It was a nightmare experience.
M Self-criticism is worse because you tend to concentrate on the negative.
Hs The first episode made me anxious.
PE The first videotape was a shock. I didn't know I looked like that.

Positive responses

E It allowed me to take the perspective of a student sitting in my class.
He I learn by seeing (so the videotape was very helpful).
E It was unbiased and comprehensive.
M I caught things during the second or third viewing that I missed during the first viewing.
M Videotape allows for self-criticism, and you see repetitive errors.
M The actual order of events within the lesson and their effectiveness were clear on the videotape.
M It allowed me to defend my actions (to the evaluator).
M It allowed me to compare my supervisor's assessment to my actions.
Hs You catch all of the "little things" that the supervisor missed.
Hs (While viewing the tape) I caught some student misbehavior that I missed while I was teaching.
Hs It was a permanent record to be referred to during consultation.
Hs (When I watch the tape) I don't have to rely on someone else's criticism.
Hs It effectively augmented my supervisor's feedback.
Hs I came up with solutions to my problems while watching my videotape.
PE I saw for myself what I did wrong and what I did right.
PE It is like they say, "The camera doesn't lie!"
PE (Being videotaped) is like a formative test. It helped me to work on my diction and on my use of slang terms.
PE While watching the tape my supervisor was able to point out to me some things that I did poorly that I had overlooked.
PE I was able to see more errors on the videotape than my supervisor had indicated in his/her evaluation of my teaching.

A consistent theme found throughout the student responses was that neither the use of videotape nor conventional supervision was perceived as being as effective as a combination of the two methods. The students' perceptions were that the optimum learning occurred when the student and the supervisor viewed the tape together and discussed the evaluation in the context of the lesson being watched.

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TELECOMMUNICATIONS

Towards a National Education Computing Network

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During the second World War Eisenhower was impressed by the utility of the German highway system, or autobahn. When he assumed the presidency in the 1950's, he chartered a similar national highway system that became today's Interstate network. This highway system was designed to facilitate movement of military vehicles in the event of a national emergency, but also had a profound effect on the movement of commercial and consumer traffic.

In the 1970's a national research computing network known as ARPANET was established. Although this computer network was established to facilitate government research efforts, it was quickly used for support of a variety of other activities. It provided the infrastructure for transport of all types of information, just as the interstate highway system provided the infrastructure for transport of all types of vehicular traffic.

Today's successor to ARPANET is a collection of interconnected computer networks collectively known as the *Internet*. Almost all major universities today are linked to the Internet, effectively providing an inter-university network connecting educational institutions in many other countries in the world as well as in the United States. The Internet also connects government agencies and commercial firms as well as educational institutions. The Internet itself is actually a collection of more than 2,000 networks in more than 40 countries which all obey a common communications protocol (Coursey, 1991; Quarterman & Hoskins, 1986).

At most universities in the United States access to the Internet is made available without charge to individual faculty or students, just as most information services in university libraries are provided without charge to the individual user. The Internet provides a telecomputing network for schools, colleges, and departments of education which links them and offers opportunities for interactions and collaborations.

Establishing Public Education Networks

The next logical step is extension of this national inter-university network to the public schools. This would form a seamless computing network extending from kindergarten through graduate school. Several states have already taken steps to establish such connections. Virginia's Public Education Network (known as Virginia's PEN) will eventually link all 2000 public schools in that state to the Internet. Under the guidance of Connie Stout, a similar model which will link public schools to the Internet has been adopted by the Texas Education Agency. In South Carolina, Project REACH is in the prototype stage of establishing a network which will link teachers throughout the state to the Internet.

In their article, "GC EduNET: Building an Electronic Community", which begins the telecommunications section, Frank Lowney and Edward Wolpert describe a plan for linking the K-12 network which they have established to the inter-university network within Georgia. They note that in parallel with similar efforts "planned by Florida, South Carolina, Texas, and Virginia, we can look forward to an electronic community of educators that spans the globe and includes educators from pre-kindergarten through graduate school."

Preservice Teacher Education

Although electronic communications are routinely employed for collaborative research in some university programs such as business administration and engineering, this tool is new to many education faculty. In "Making Connections: Telecommunications for Teacher Educators", Diane Kester describes a methodology for introduction of telecommunications to education faculty, based on experiences with the network established by Al Rogers, FrEdMail (Free Educational Electronic Mail Network). The FrEdMail system is more loosely structured than the Internet, and is based upon transmissions among microcomputer-based nodes in public schools in the United States and other countries. Although the FrEdMail system utilizes a different communications protocol than the Internet, efforts are underway to establish a gateway between this system and the Internet.

Sue Anderson notes that attitudes are as important as technical considerations during introduction of new technologies, describing her findings in "Computer Attitudes, Experience, and Usage of Computer Conferencing by Preservice Educators." Students in the teacher education program at the University of Virginia receive an introduction to electronic mail and conferencing and a network ID in their first education course. Anderson's findings were consistent with other studies which have found that attitudes toward computers were significantly associated with the degree to which computer-mediated communication systems were used by preservice teachers.

The instructional content of activities which take place over a network is also important. In "Interactive Communications and Simulations: the Global Classroom", David Anderson and David Bair describe interactive computer simulations developed at the University of Michigan. Simulations such as the "Arab-Israeli Conflict" allow students at many locations around the world to adopt the role of characters with diverse perspectives. Several of these exercises link K-12 schools to institutions of higher education.

Michael Young and Curtis Ho describe use of the Internet to support collaborative efforts between students in the education program at the University of Connecticut and students at the University of Hawaii. In "Anchored Instruction in the Educational Uses of Telecommunications", they observe that education students in their respective courses learned about telecommunications in the context of an actual project. This initiative involving two instructors separated by several thousand miles brings a new meaning to the term "team teaching", and is suggestive of the instructional potential afforded by similar collaborative efforts via the Internet.

Michael Waggoner and Thomas Switzer brought extensive experience with the University of Michigan conferencing system to the education program at the University of Northern Iowa. There they are using computer conferencing to provide support for student field experiences, student teaching, and for the induction year of first year teachers. (Provision of support for the induction year was also the rationale for establishment of the Texas network.) Based on their experience, Waggoner and Switzer describe both the problems and promise entailed in establishing such a system in "Using Computer Communications to Enhance Teacher Education."

Inservice Teacher Education

As Waggoner and Switzer note, telecommunications networks offer extended opportunities for support of in-service education as well as pre-service education. Shahnaz Lotfipour and S. Pike Hall describe use of an electronic bulletin board to reduce direct classroom contact required for an in-service course by half. In "The Electronic Bulletin Board and Off-Campus Extension Courses" they report that this allowed them to interact with teachers in their classrooms during the lunch hour or after school. The reported benefits were personalized instruction while permitting the teachers to learn at their own pace.

Mark O'Shea, Howard Kimmel, and Lisa Novemsky summarize several prior initiatives involving support of instruction via a network, and describe an in-service program which they developed for elementary and middle school science teachers. In "Continuing Education for Teachers through Electronic Conferencing" they outline a program in which veteran teachers attend Saturday morning workshops at six-week intervals, supplemented by interim support via electronic conferencing and mail. Teachers participated in hands-on investigations related to a science theme which they selected for the year, and used the network to share data gathered by students.

Glen Bull, Margie Mason, Bernard Robin, and Tony Wayne describe a similar project designed to provide support for elementary and middle school science teachers via Virginia's Public Education Network (PEN) in "Establishing a Peer Mentor Science Network." This system allows high school science teachers to serve as mentors, through personal visits and via the network, to elementary and middle school teachers. Physics professors at universities and other personnel from museums and government agencies such as NASA also provide electronic support via the Internet.

The term "telecommunications" encompasses communication at a distance via any medium, including computer networks, audio conferences, and televised courses. Barbara Hakes is using two-way video and audio as well as a computer network to provide support for isolated teachers in Wyoming. In the world of multimedia it is becoming increasingly common for computers and interactive video to be used in combination with one another. The work described in "Two-way Video and Audio: Removing the Walls of Schools and Teacher Preparation Institutions" extends this trend to the area of telecommunications.

Towards a National Education Network

The articles in this section illustrate the rich variety of resources which are being developed to support instruction via telecommunications. There is an increasing awareness among education faculty that an inter-university network, or Internet, already links most schools, colleges, and departments of education. The next logical step is to extend this existing telecommunications system to the public school.

There is considerable benefit to having universities and public schools on a common network. Collaboration between education programs at universities and the public schools is fostered by utilization of a system that extends from kindergarten through graduate school. This has the further advantage that a teacher in Virginia will be readily able to communicate with a teacher from Texas, for instance. The Internet also offers a variety of other educational resources extending across this international network, ranging from government agencies such as NASA and the Environmental Protection Agency to university library catalogs and databases. For example, when the connection between the Georgia College Educator's Network (GC EduNET) and the Internet is made, it will be possible for teachers with connections to the Internet in other states to access the range of educational resources which have been made available on GC EduNET.

In some states public school networks are being established which are incompatible with the existing Internet. Without a gateway to the Internet, these networks may become the equivalent of electronic cul de sacs. The ability to send an electronic message to anyone in the public schools or higher education via a common protocol would considerably enhance the value of an educational telecomputing system. This does not imply that every state must use the same network, but simply that each system should follow a common communications protocol so that it is possible for a message to transparently move from one network to another. This, in fact, is the method adopted by the telephone system. A long distance phone call from one state to another involves at least three different telephone companies (the local carrier at each end as well as the long distance carrier), but the switching from one network to another is transparent to the user

Efforts to establish public school networks linked to the Internet in a number of states are encouraging. EDUCOM has recently initiated a project titled "Towards a National K-12 Network" directed by John Clement which may facilitate these efforts. Similarly, the National Research and Education Network (NREN) proposed by Senator Albert Gore would extend the network to the high school level. By the beginning of the next century public school access to a nationwide K-12 network may be as common as access to the school library.

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GC EduNET: Building an Electronic Community

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The Problem

The professional isolation of teachers is a well documented phenomenon (Daresh, 1988; Flinders, 1988; Tye, 1984; Rothberg, 1985). In order to access, maintain and extend their knowledge base, professionals in any field must have ample opportunities to interact with those who are dealing with the same situations that they are. They need to be able to compare notes, share ideas, strategies and materials, and support one another in a wide variety of ways. This is no less true for educators, especially classroom teachers, than any other group of professionals.

In contrast to most other professionals, teachers are unlikely to attend conferences and professional meetings on a regular basis at which events they could interact with their colleagues, sharing ideas, materials, beliefs, problems and successes. Most interaction, if it is to occur at all, takes place on a limited, random, unplanned, catch-as-catch-can basis. This unfortunate situation is attributable to the fact that funding is seldom available either for teachers to travel to these events or for substitute teachers to cover their classes.

Although schools and colleges of education represent a vast reservoir of potential resources for the K-12 community, they are all too often unable to fund the delivery of enough of those resources to make a significant impact. Conversely, these schools and colleges of education are impoverished by the lack of regular opportunities for contact with the K-12 community. It is the experience of the authors that teachers do indeed want to communicate with one another and with resource persons in higher education but are often frustrated in their attempts to do so. The same may be said for the wish of many in higher education to interact with members of the K-12 community.

The GC EduNET Solution

Since it is cheaper and easier to move information to people rather than move people to information, the deisolation of teachers and administrators becomes economically feasible if telecomputing technology is used in place of physical transportation. The ubiquitous microcomputer equipped with a modem and accompanying software is an excellent vehicle for reducing the isolation of educators through the use of well-established telecommunications technology.

Computer networking among teachers is not a new idea, although its use is not by any means widespread. The Harvard Graduate School of Education initiated an electronic bulletin board service (BBS) for its first year teachers which allows e-mail conferencing among teachers and Harvard faculty (Rodman, 1988). A similar network was set up by the schools of education of the University of Virginia (Bull, 1988) and the University of

Michigan (Swift & Coxford, 1988) for student teachers. Western Montana College's Big Sky Telegraph project (Odasz, F., personal communication, 1988) and the University of Northern Colorado school of education's UNCLE project (Lounge & Walker, 1988)) add resource sharing to the networking activities provided by the other BBSs mentioned.

The GC EduNET Design

GC EduNET (Georgia College Educators' Network) was developed to bring educators together with each other and with various resources thought to be of interest and value to them. This service was designed to reduce the isolation of Georgia's teachers and administrators by providing the capability for electronic conferencing, electronic mail, file sharing, on-line database searching, and various other communicative activities. The service is free to all schools in Georgia. No membership or connect-time fees are levied and telephone charges are taken care of through the use of several toll-free lines. These attributes reflect the following design criteria: First, the system had to be considered accessible by a majority of teachers and teacher support personnel in the K-12 community, many of whom had not yet had their first computer experience. That is, our constituency would have to be able to honestly say, "Yes, I can do this" after a demonstration of GC EduNET and an opportunity to engage in guided practice. Second, and equally important, the opportunity to acquire information and communicate with other educators had to be considered worthwhile. That is, no matter how easy we might make using this technology, it would have to yield benefits judged by teachers to be greater in value than the time and effort needed to achieve them.

A key feature of GC EduNET which distinguishes it from other services is its comprehensive approach to teacher deisolation. In its original configuration, GC EduNET was merely another BBS. But after a short period of time the realization was made that teachers and administrators needed more than just e-mail and conferencing. They needed access to documents and information that they could not as individuals generate themselves. Accordingly, GC EduNET was reconceptualized from a BBS to an electronic information service (EIS).

The difference between a BBS and an EIS is quite significant. A BBS simply provides an arena for members to post information and files for other members to view and possibly capture or download. The role of the BBS is to facilitate this kind of sharing An EIS on the other hand, goes beyond e-mail and forums by collecting, organizing and re-presenting information from nonmembership sources. In other words, an EIS proactively adds value to the electronic information base. Under the direction of the system administrator for GC EduNET, for example, documents from the state department of education such as the Quality Core Curriculum are identified as being of interest to the membership and are included in one of EduNET's libraries with linkages to other, related resources. As another example, the daily curriculum guides for the CNN Newsroom are solicited by GC EduNET and are made available to its members at 6:00 AM each school day. Keyword searchable databases such as course offerings are made available to the membership. The proactive role of GC EduNET in seeking out sources of information, amplifying its utility and making them available to its membership is a major distinction between GC EduNET and other services.

Beyond the decision to extend the service from a BBS to an EIS several other strategic decisions were made in designing this service. First, since the vast majority of the potential clientele would be teachers many of whom might very well be reluctant to use a computer in any fashion, it was decided to make the system as user friendly as possible. This included easy to follow directions, frequent unambiguous prompts, user tutorials on demand and the like. The system exudes warmth and friendliness. Second, since there is a variety of hardware used by the potential membership, it was decided that the system be designed to allow access from any and all platforms—IBM, Apple, Macintosh, Commodore, etc.

Third, the reality of our potential member's finances had to be addressed. Most teachers, whether at home or school, simply will not use an EIS (or for that matter, a BBS) if they have to pay for telephone toll charges. So, GC EduNET makes the service available using three 1-800 numbers, not only making the service available with no toll charge, but in addition giving reasonable assurance that the caller will not be greeted with a busy signal when the call is placed. In addition, it should be noted that there are no membership fees or access charges. A fourth decision dealt with the scope of the potential membership. At the beginning, GC EduNET was financed as a major project of the Regional Teacher Education Center at Georgia College (RTEC at GC), but such financing only allowed the provision of GC EduNET's services to teachers and schools within the fifty mile radius service area of the college. It is believed that for an EIS such as ours to be truly effective, there must be a corpus of teachers and administrators sufficiently large to promote enough interest and interaction to justify the fixed cost resources allotted to it. The involvement of information providers and information consumers in the proper proportions was deemed crucial. The state funds allocated by RTEC were not sufficient to support the new membership which would be recruited by increased efforts. A generous grant from the BellSouth Foundation when added to the existing RTEC funding allowed EduNET to expand to include teachers and administrators in the entire state of Georgia.

Performance

Membership statistics, which are changing on a daily basis, indicate that there are currently more than 1635 members (up 93% over the previous year) in GC EduNET representing 101 counties in Georgia (up 20% over the previous year). Seventeen percent of the membership are classroom teachers with secondary teachers predominant followed by middle school and elementary teachers. K-12 and college students comprise 18% of the membership. K-12 administrators, support staff and college personnel comprise 35% of membership with, not surprisingly, school library media staff and curriculum coordinators especially well represented. Other members include parents, counselors, military and civil service personnel.

In addition to the familiar e-mail and conferences, GC EduNET's services include the following:

1) Libraries: this section contains reference information from a variety of sources including the State Department of Education. There is a Positions Wanted/ Positions Available section which serves as a classified employment section for teachers and personnel directors; there is a section for counties to post information for their teachers and administrators with access restricted to only those people; there are other sections as well.

2) Questions and Answers: this is an extended version of e-mail. A member who has a question on a specific topic asks the question which is routed for an answer to one of many Georgia College faculty who are participating in the program. The faculty member answers the question by e-mail or by phone as desired by the questioner.

3) Electronic Marketing: members may offer to buy or sell a variety of non- commercial items through advertisements generated in this section.

4) Center for Adolescent Needs: this is a special section for Georgia College's Innovative Teaching Center for Adolescent Needs to provide data bases and other references for members who need specific information .

5) Software and File Exchange: program specific files and executable programs may be downloaded for use on a specific computer.

6) Organizations: this is a special section for educational organizations (e.g. Georgia Association of Educators) to communicate and share information with their membership.

Usage statistics indicate that the CNN Newsroom Curriculum Guides feature is the most popular closely followed by e-mail and conferences. Monthly usage during the school year has been averaging more than 2500 calls per month with an average duration of ten minutes which gives a total of 416 hours on line monthly. Each month (except for summer months), membership and usage increases over the previous month.

The Technology

GC EduNET is an information system that works in conjunction with an AppleTalk network. The primary file server is a Macintosh IIx with a 160 Mbyte internal hard disk. Additional hard disks and file servers bring the total storage capacity to well beyond 330 Mbyte. The network itself is composed of a number of terminals on the desks of faculty and graduate assistants (either an Apple IIgs, an Apple Macintosh or an MS DOS clone) in the school of education and several terminals (Apple IIe) serving as telecommunications ports. GC EduNET will support multiple, simultaneous access to selected portions of its information base through these telecommunications ports. It is through these ports that educators in our service area and beyond access the many features of GC EduNET. GC EduNET is unique in that it is a local area network which may be accessed remotely.

Both internal and external access to GC EduNET features is managed by conventional AppleShare protocols plus software developed jointly by ITS of Atlanta and Russ Systems of Santa Cruz, California. The ITS/ Russ Systems' software extends the AppleShare system through the use of a simple, but versatile, scripting language. Scripts generated by this very easy to learn language control the collection, organization and presentation of information throughout the network. Thus, electronic mail, conferencing, searchable data bases, surveys, testing, tutoring, and a host of other important features are easily implemented by faculty who have no training in computer programming. Access to view and/ or modify these information "presentations" is fully configurable regardless of whether that access is internal or remote in origin.

Since any modem that can emulate a TTY (teletype) device can also interact with GC EduNET, nearly universal access is assured. To further this accessibility, several WATS lines were provided that were configured so that they would "roll-over" to the next available line when busy [In Georgia: (800) 642-7375 (toll-free) Outside Georgia: (904) 453-1897 (toll charge)]. Thus, school personnel were afforded convenient, low-cost access to an information service that enables them to confer with one another individually or in groups as well as to acquire and share a broad range of education-oriented information.

The Future of GC EduNET

The development of GC EduNET was planned in several overlapping stages. In Stage I, an information and communication service for Georgia K-12 teachers and administrators and support personnel would be launched. The services available on this system would have to be perceived by these professionals as easily used and worthwhile. In Stage II, involvement of the largest possible number of information providers and information consumers in the K-12 education community would be sought. This would be to achieve the communications analog of critical mass at which point the reaction of sharing ideas, materials, strategies, and other forms of support would become self-sustaining. In Stage III, every avenue to expand the access to GC EduNET by all classroom teachers would be explored. Without impacting the largest possible number of classroom teachers, achieving the first two objectives will be of very little value.

So, how are we doing?

We have completed Stage I by designing a system accessible to any modem-equipped computer.This system is flexible enough to respond to the wide variety of information and communications needs characteristic of the K-12 education community, and friendly enough to encourage use by all but hard core computerphobes. While the hardware and software will, no doubt, evolve as new and better technologies become available to us, it is the human resources, the "wetware"*, that will remain an ever-growing need. The organization and financing of wetware resources to cultivate the information base of GC EduNET is the sine qua non of the continued success of the network.

Progress on Stage II was given a big boost by the expansion of the mission of GC EduNET to statewide proportions. The BellSouth Foundation grant and an additional grant from GTE have been instrumental in making this possible. In a new and very helpful development, the University System of Georgia is in the final stages of developing PeachNET, a network linking all 33 state institutions of higher education. As GC EduNET becomes a resource on PeachNET, this will complete the realization of Stage II by effectively linking Georgia's K-12 education community with the worldwide higher education network. As other states do likewise, as is planned by Florida, South Carolina, Texas and Virginia, we can look forward to an electronic community of educators that spans the globe and includes educators from pre-kindergarten through graduate school. Additionally, PeachNET will significantly expand the potential for higher education to assist the K-12 community reach its goals and do itself a favor in the bargain by assuring the supply of qualified college and university students.

Stage III, ensuring access to all classroom teachers who desire it is progressing slowly. Access involves two factors, motivation to use and availability of equipment. Marketing GC EduNET to classroom teachers many of whom are at best neophytes in matters concerning computers has become, as was expected, a formidable task. While much has been accomplished in this critical area, much remains in order to realize fully the potential of GC EduNET. The network staff has been trying a variety of ways to get teachers interested and involved; some ways work better than others.

Regarding availability of equipment to teachers, it has turned out that the last 200 feet, the distance from the school office to the teacher's classroom, is the most difficult to traverse electronically. Classroom teachers remain the only professionals without convenient and easy access to a telephone. While there are still few classrooms with modem-equipped computers, the number of modem-equipped schools is significant and growing. But the scholar works in many vineyards, especially in the home. It is at home that most teachers accomplish much of their professional non-teaching responsibilities, and it is at home where teachers have extended periods of quiet time and a dedicated phone line to have their computers interact with those of other professionals. This is the venue promising the greatest rewards. Stage III will approach completion when a significantly large number of teachers have a modem-equipped computer in their homes.

*the human brain is mostly water

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Making Connections: Telecommunications for Teacher Educators

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Funding for computers, videodisc players and discs, CD-ROM drives, and application software usually reach the K-12 setting before they are available in teacher education programs. In 1983 the North Carolina state legislature funded a three-year program to provide computers in all the K-12 schools. However, the institutions of higher education with teacher education programs were not included in this generous attempt to encourage the use of technology in education, even though the demand for additional training and courses in computer competencies swelled. Colleges of education were unprepared to offer hands-on opportunities with quality educational and application software.

The first to begin to meet this need were the departments offering courses in audiovisual education where computer usage was added to the curriculum. In the last five years, courses in the use of computer software to introduce, instruct, drill, and review subject competencies have become standard, if not required, in teacher preparation programs.

One particular use of computers has been growing as school media specialists and classroom teachers explore the world outside the walls of the school. As in academic libraries, school media specialists provide access to materials in electronic databases and news services. The vendors of these services have come to recognize that school media programs provide natural learning opportunities to use computers and telephone connections to obtain references and materials for projects and term papers.

FrEd is Born

While teacher educators were struggling to obtain the hardware that the schools were already using, schools were not marking time. Using research conducted at the University of California in San Diego, the CMS School-Net Networking Project was developed to encourage student writing by providing incentives in the form of specific projects and use of computers to share writing with other students. Al Rogers discovered CMS (Computer Mail System) on a local bulletin board and recognized the potential for the educational community. He revised the program, and established the FrEdMail Foundation which operates the Free Educational Electronic Mail Network, FrEdMail. This service is a *dynamic*, rapidly growing, grass-roots telecommunications network that links schools, students, and educators around the world. Accounts are free. The only cost is the charge of a phone call to the nearest FrEdMail node.

The goals of the Foundation are:

"1) To promote a better understanding of telecommunications technologies and to encourage their effective use in classrooms around the world
2) To assist students in the acquisition of effective communications skills (reading, writing, and thinking) at all grade levels
3) To promote the development of cultural, geographical, and socio-political awareness and understanding on a global scale
4) To encourage articulation between all aspects of the community (such as universities, health agencies, and service organizations) in order to bring those agencies into a closer partnership with K-12 schools
5) To foster the development of a low cost, community-based, electronic communications network owned and operated by public agencies such as schools, libraries, cities and other community service organizations, so that all citizens may have electronic access to information." (*FrEdMail Getting Started G:' '*, nd, p. 3)

FrEdMail Uses

To accomplish these goals, FrEdMail provides an effective vehicle for transmitting student writing from one place to another. It can be used at any grade level and in any subject area. Real audiences are provided with real purposes for writing. How does it work?

Projects are developed by teachers and are coordinated with other teachers who participate in the network. Students do their writing using a word processing program. The results are sent electronically in batches at night when the CMS nodes dial each other and exchange messages. "FrEdMail emphasizes specific, purposeful, well-planned collaborative learning activities which encourage interested, productive participation by students and teachers." ("Getting Started with FrEdMail", nd, p. 1)

Using a computer, communications software (often FrEd Sender, written by Al Rogers), a modem, and a telephone, the media specialist or teacher dials a local or nearby number. The phone rings in a central office or teacher education computer lab where the host computer answers the call and, with a few keystrokes, the building level educator has opened the doors to communications limited only by the imagination.

Purpose of FrEdMail

The primary purpose, to encourage writing, is facilitated by teachers collaborating with other teachers via the electronic system. Beyond the obvious language arts projects, teachers are finding that electronic communication is motivational in other subject areas as well.

Examples of such projects include:

- A county-wide newspaper of school news items and creative writing;
- A book of riddles compiled from students within a district;
- Data gathering to compare prices on common grocery items leading to various classroom activities using the data;
- "Sister classes" to exchange regional and cultural information;
- Sharing of book critiques, plays, events, etc. with students in other schools;
- Sharing of information about colleges, universities, and technical or trade schools;
- Collection of weather data over a period of time which was shared with students in different areas;
- Development of a travel brochure for their town which was shared with other students;
- Exchange of recipes of local dishes.

Teacher Use

One of the first things teachers do upon arriving at school, is to check their electronic mail (e-mail). Personal messages concerning suggestions for class activities, addresses of resources for the curriculum, answers to questions left for other educators, or messages from the FrEdMail node system operator (SYSOP) are read. A check of the bulletin boards is next. The classroom teacher may check for NEWS or IDEAS. It may be that the class has been working on a project with another classroom in another state and the response has arrived. What excitement when the students read their messages from students across the country! These messages are saved and printed out for individual students. After ending the session, the teacher faces the day with renewed enthusiasm, just as the students do. Telecommunications is a motivating factor in education.

Why Telecommunications in Education?

The results of a recent project, Vision: TEST (Technologically Enriched Schools of Tomorrow), cites evidence of technology's effectiveness, identifies elements of school restructuring required to make effective use of technology, provides major recommendations, and includes contributions of business. The IBM Educational Systems Division awarded the International Society for Technology in Education (ISTE) a grant to study the potential that technology offers to education.

Two findings of this study are applicable to teacher educators.

- Well-trained teachers making effective use of technology offer the capability of dramatically improving the learning experiences of all students.

- Teachers need substantial training, support, and time to integrate technology into their curricula. (*Vision: TEST*, 1990, p. 8)

In their Recommendations for Educational Decisionmakers, the project addresses preservice teacher education. "Teacher education programs must be designed to prepare prospective teachers to move into classrooms with rich, technological support." (*Vision: TEST*, 1990, p. 12) (A copy of the *Vision: TEST Final Report*, is available for $13.25 from ISTE, 1787 Agate Street, Eugene, OR 97403.)

Benefits of Telecommunications

The Media and Technology Services division of the North Carolina Department of Instruction summarizes the benefits of telecommunications in its publication, *Telecommunications - First Primer* (1988). The medium:

- creates motivational activity
- provides audience for writing
- provides experience for reading
- provides practice for improvement of reading rate
- provides practice in recognizing main ideas and sequencing
- develops comprehension skills
- develops computer operational skills
- develops skills for the future
- develops vocabulary
- broadens information base
- refines reference skills
- develops decision making skills
- develops critical thinking skills
- introduces application of computer skills in society

Studies and Examples

A recent study involving writing skills was conducted with a group of sixth graders in North Carolina. Writing and editing were taught with the aid of word processing. Students communicated electronically with a school on an Indian reservation in Washington. Writing assessment tests were administered in the fall and the spring. Sixty-four percent of the students improved on descriptive writing after using electronic mail (Ramsey, 1990)

A project between fourth and fifth year students in New South Wales and an elementary school in Pennsylvania offered experiences in reading and writing, cooperation and collaboration, and eventually the exchange of local items (Butler & Jobe, 1987).

Conclusion

This paper has been limited to a discussion of an electronic messaging system that was created to encourage writing by students. There are several general categories of communications services in addition to electronic mail services. Database services are used through the library media services to identify bibliographic listings, sources of information, and the answers to reference questions. Information services are provided by commercial vendors and may provide special interest forums ranging from Amiga to zoology. Private bulletin board services are provided by citizens, small businesses, clubs, and libraries throughout the country. Authors are transmitting their articles, books, and reviews from their own computers to the publishers' computers using telecommunications.

If we are indeed preparing teachers to be able to teach students effective in the future, we must prepare them for the use of technology in many environments. In a series on technologies written for business managers, one title was devoted to e-mail. Caswell (1989, p. 2) writes, "Companies whose top management has adopted electronic mail and related office automation technologies have reported some dramatic stories where electronic mail has given them a competitive edge." Can we do less than provide experiences for teachers who will in turn provide opportunities for students to have a competitive edge?

Terms of electronic mail

Baud rate - The speed at which data is communicated

BBS - Bulletin board system

Bulletin board - a computer service where users may post electronic bulletins for other

Carrier - A continuous tone sent by the host computer

CMS - Computer mail system

Database - In formation stored in an electronic filing system

E-mail - Electronic mail

File - A set of related records treated as a unit

FrEdMail - The name of a public domain educational CMS

FrEdSender - A public domain telecommunications program

FrEdWriter - A public domain word processing program

Host computer - The controlling computer in a network

Hub - A central BBS to which other nodes are connected

Logoff - The procedure by which a user ends a network session

Logon - The procedure by which a user begins a network session

Modem - A device used to connect computer equipment to telephone lines

Network - A group of processors and terminals serving several users at once

Node - A point on the network where transmission lines are interconnected

Off-line - Not connected to the hose computer

On-line - Directly connected to the hose computer

Password - A string of characters supplied by the user to gain access to the system

Path - The route between any two nodes in a network

SYSOP - SYStem Operator, the person who manages a BBS

Username - The name by which a user of the network is identified

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Computer Attitudes, Experience, and Usage of Computer Conferencing by Preservice Educators

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Despite the presence of computers in most schools, only about half the nation's teachers report having ever used computers and the percentage that use computers regularly is much smaller (U.S. Congress, Office of Technology Assessment, 1988). The National Education Association's Educational Technology Report (1989) has called for a computer on every teacher's desk, asserting that "only when teachers begin using computers on a personal basis will schools experience an upsurge in teachers' use of technology" (p. 12). Introducing preservice teachers to computer conferencing may be one way to encourage them to "embrace technology as part of their everyday lives" (IBM, 1989) which may then lead to higher rates of computer usage in their future careers.

Computer-mediated communication tools, such as computer conferencing, have become increasingly important and accessible to the educational community (Clark, 1988; U.S. Congress, Office of Technology Assessme..t, 1988). Successful implementation of this type of communication technology requires a "critical mass" of active users (Rogers, 1986). Thus it is important to identify factors associated with the degree to which this technology is used. These factors may be similar to those which affect usage rates of other computer applications.

Computer Experience and Attitudes

Familiarity with computers may be related to positive attitudes toward them and therefore, less resistance to using them. Research has demonstrated that experience with computers is positively related to attitudes toward computers for several groups: high school and college students (Loyd & Gressard, 1984b); undergraduate education students (Koohang, 1989); teachers (Loyd & Loyd, 1985); and early childhood administrators (Jorde-Bloom, 1988). In addition, participation in computer-related training activities has been associated with significantly improved attitudes toward computers for preservice teachers (Chapline & Turkel, 1986) and teachers (Gressard & Loyd, 1985; Madsen & Sebastiani, 1987).

Computer Experience and Usage

It is unclear whether experience with computers is directly related to computer usage or whether .. is indirectly related to usage through it's influence on attitudes. Jorde-Bloom (1988) demonstrated that previous experience with and knowledge of computers was significantly related to subsequent use of computers by early childhood administrators. Malaney and Thurman (1989-90) found that prior computer experience was related to frequent microcomputer use for college students, but Arch and Cummins (1989) found this to be true only for female, but not for male college students. In contrast, previous experience with computers was not related to female college students' intentions to enroll in computer-related courses (Hill, Smith & Mann, 1987) or commitment to use computers by (predominantly female) student teachers (Kay, 1990).

Computer Attitudes and Usage

Individuals who feel comfortable with computers and confident about their ability to work with them may be more likely to use them. Attitudes toward computers were a significant predictor of computer usage for student teachers (Kay, 1990) and early childhood administrators (Jorde-Bloom, 1988). Additionally, college students with more positive attitudes toward computers tended to spend more time using microcomputers and mainframe computers (Yi-Kuo & Morgan, 1989) and tended to use computers to complete optional assignments more frequently (Fann, Lynch, & Murranka, 1988-89) than students with less positive attitudes. Finally, Koslowsky, Lasar, and Hoffman (1988) found that only one of two attitudinal factors was significantly correlated with number of computer sessions and amount of student-computer interaction time for college students taking a required computer course. This was the only study reviewed that employed computer-generated usage measures.

Overview of the Study

The literature suggests that experience with use of computers is related to attitudes toward them and that attitudes toward computers are related to the extent to which individuals use computers. It is unclear whether experience with computers is associated with computer usage. In this study, the relationships among experience with computers, attitudes toward computers, and usage of a computer conferencing system were examined. It was hypothesized that experience would be positively related to attitudes and that both experience and attitudes would be positively related to usage of a computer conferencing system.

Method

Participants

Participants were 68 (60 female and 8 male) second year undergraduate students enrolled in an introductory "Teaching as a Profession" course during their first semester in the teacher education program at the University of Virginia. As part of the course, students attended six 90-minute training sessions during which they were taught computer applications such as word processing, database searching, electronic mail, and computer conferencing. A computer conference was established for communication related to the course and students were encouraged to use it on a regular basis, though their participation was voluntary.

Measures

Students' attitudes toward computers were assessed after completion of the six computer training sessions using the Computer Attitude Scale (CAS) (Loyd & Gressard, 1984a). A question about previous computer experience was included with the CAS. Participants were assured that their responses would remain confidential. Two students did not complete the attitude questionnaire and six students did not respond to all the items and thus were not included in all of the analyses.

The CAS consists of three (10 item) subscales: Computer Anxiety, Computer Confidence, and Computer Liking. Possible CAS scores can range from 30-120, with higher scores indicating more positive attitudes. The CAS has been shown to possess satisfactory internal consistency (Loyd & Gressard, 1984a), stability (Roszkowski, Devlin, Snelbecker, Aiken, & Jacobsohn, 1988) and convergent validity with other computer attitude instruments (Dukes, Discenza, & Couger, 1989).

Two measures were used to assess usage of the computer conferencing system. A record of each time an individual accessed the conferencing system was stored in a log file on the computer and discussion responses entered by each student were automatically recorded and stored on the computer conference. The number of times students logged on (sessions) and the number of discussion responses they entered on the conferencing system (entries) were computed over a nine week period.

Analysis

Pearson product-moment correlations were calculated for the total sample to assess the relationships among computer attitudes, experience, and the two measures (sessions and entries) of computer conferencing usage. One-way analysis of variance (ANOVA) procedures were used to determine whether groups representing three levels of computer experience (less than 6 months, 6 to 12 months, and more than 12 months) differed on computer attitudes and computer conferencing usage, and whether groups representing three levels of computer attitudes (characterized as negative, slightly positive, or very positive) differed on computer conferencing usage. Post hoc analyses were conducted using the Tukey B procedure.

Results and Discussion

Students' attitudes toward computers as indicated by CAS total scores were generally positive (mean = 83.78, SD = 17.54). Students' usage of the computer conferencing system varied greatly, ranging from 0 to 69 sessions (mean = 13.82, SD = 14.53) and from 0 to 53 entries (mean = 4.81, SD = 7.68). Frequency distributions for sessions and entries were positively skewed. Table 1 displays correlations coefficients for computer experience, CAS subscale scores, CAS total scores, and computer conferencing sessions and entries.

Table 1
Pearson Correlation Coefficients Between Computer Experience, CAS Subscale and Total Scores, Computer Conferencing Sessions and Entries

	Experience	Sessions	Entries
Experience	—	.02	.08
Anxiety	.47***	.26*	.29*
Confidence	.51***	.26*	.36**
Liking	.32**	.29*	.38**
CAS Total	.48***	.30*	.38**

Note. * p < .05, ** p < .01, *** p < .001, two-tailed.

Experience with using computers was expected to be related to attitudes toward computers and, in turn, computer usage. Result were consistent with the findings of previous studies (Chapline & Turkel, 1986; Gressard & Loyd, 1985; Jorde-Bloom, 1988; Koohang, 1989; Loyd & Gressard, 1984b; Loyd & Loyd, 1985; Madsen & Sebastiani, 1987) and indicated that computer experience was significantly related to computer attitudes (r = .48, p < .01). Results of the ANOVA indicated that groups representing three levels of experience (see Table 2) differed on attitudes toward computers (F = 9.09, p < .001). Post hoc analysis revealed that the group with less than 6 months of experience differed significantly (p = .05) on computer attitudes from groups with 6 to 12 months and more than 12 months of computer experience.

Contrary to expectations, experience with computers was not directly related to either measure of computer conferencing usage. This contrasts the results of some studies (Arch & Cummins, 1989; Jorde-Bloom, 1988; Malaney & Thurman, 1989-90) and is consistent with the results of other studies (Hill, et al., 1987; Kay, 1990). The correlations between experience and measures of computer conferencing usage were low (r = .02 and .08) and non-significant. Results of the ANOVA procedures were also non-significant for sessions (F= 1.69, p = .19) and entries (F = 1.34, p = .27). (See Table 2 for the means and standard deviations of these groups representing different levels of computer experience.)

Table 2
Means and Standard Deviations of Computer Attitudes and Computer Usage by Amount of Experience

	Amount of Experience		
	< 6 mo.	6-12 mo.	> 12 mo.
CAS Total	(*n*=13)	(*n*=9)	(*n*=33)
Mean	70.94	85.67	90.27
SD	9.46	13.33	18.38
Sessions	(*n*=20)	(*n*=10)	(*n*=36)
Mean	11.75	21.70	13.28
SD	11.23	25.18	12.15
Entries	(*n*=20)	(*n*=10)	(*n*=36)
Mean	3.20	8.10	4.94
SD	4.67	16.09	5.41

As expected, attitudes toward computers were related to the extent of computer conferencing usage. Students with more positive computer attitudes tended to use the conferencing system more frequently and enter more discussion responses than those with less positive attitudes. This is consistent with the findings of previous research (Fann, et al., 1988-89; Jorde-Bloom, 1988; Kay, 1990; Koslowsky, et al., 1988; Yi-Kuo & Morgan, 1989). Significant correlations were found between computer attitudes and sessions (r = .30, p < .05) and between computer attitudes and entries (r = .38, p < .01). Results of ANOVA procedures demonstrated that groups representing three levels of computer attitudes (see Table 3) differed on number of sessions (F = 3.24, p = .046) and number of entries (F = 5.22, p = .008). Post hoc analysis revealed that the group with negative computer attitudes differed significantly (p = .05) on entries from the group with very positive computer attitudes and that no two groups differed significantly (p = .05) on sessions.

Table 3
Means and Standard Deviations of Conferencing Sessions and Entries by Computer Attitudes

	Level of Computer Attitudes		
	Negative (*n*=21)	Slightly Positive (*n*=19)	Very Positive (*n*=20)
Sessions			
Mean	10.80	11.00	21.15
SD	14.09	10.74	18.16
Entries			
Mean	1.52	4.11	9.00
SD	1.25	4.31	12.23

Conclusion

These results suggest that students' attitudes toward computers should be considered when training preservice educators to use computer applications such as computer conferencing. Increasing students' experience with computers is likely to improve their attitudes toward them, which may then lead to greater usage of computer applications such as computer conferencing. Other efforts to improve students' attitudes toward computers, such as pacing instruction to ensure initial positive experiences and creating a relaxed, non-competitive atmosphere during training sessions may also lead to increased computer usage. Further investigation of methods to improve attitudes towards computers and of other factors that may be related to usage of computer applications such as computer conferencing is suggested.

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Interactive Communications and Simulations: The Global Classroom

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Overview

In this age of "computer literacy," "information literacy," and "technological literacy," the use of the computer to develop alternative approaches to instruction is an important topic. However, too often the computer is only used as a tool for storing and processing information. The "communications" capabilities of computer and computer networks are not given sufficient attention. The system called "Interactive Communications and Simulations" (ICS), developed at The University of Michigan, provides a valuable context into which diverse perspectives can be integrated and encouraged in an active dialogue setting.

ICS consists of computer-based "conferences" which provide an alternative forum for discussion of classroom issues outside of the typical classroom environment. Since ICS uses computer networking, it includes schools all over the world and involves both secondary and postsecondary student-participants. Over 350 schools have participated over the past 8 years. In any one semester, over 1250 students from 100 schools are involved, with almost 200 schools participating over the course of the year. The network encompasses schools in 27 states within the U.S., three provinces in Canada, and 20 countries overseas. Most of the schools in those 20 countries are either members of the U.S. Department of Defense Dependents Schools network, or are International Independent Schools abroad. However, there is some participation by indigenous schools in Germany, Israel, and Singapore. The schools represent all types of communities (rural, urban, suburban, etc.) as well as public and private schools. "The network has from time to time included populations as diverse as a military school, a boarding school run by the Society of Friends (Quakers), an adult continuation school aimed at helping those who have dropped out of high school achieve their high school degrees, a private day school for girls, a school for students who are being incarcerated for crimes as serious as murder, a school that still proudly includes the term 'Latin School' in its name, classes for deaf students, and a great many classes for 'gifted and talented' students." (Goodman, 1991, p. 3) Thus, ICS is truly a new type of "Global Classroom."

ICS Exercises

There are four types of ICS exercises:

1) Simulation exercises;
2) Communications exercises;
3) Combinations of Simulations and Communications exercises;
4) Combinations of Simulations and Case Studies.

The earliest-developed type of ICS exercise is called a "simulation," consisting of "character" or "role" playing discussions. "Character playing" refers to a situation where the student is asked to research a prominent historical or contemporary figure and participate in the computer conference as that "character" would. "Role playing" refers to the situation where the student participates in an abstract role (such as "President of the United States," without specifying any particular President, or "high school teacher", without specifying a particular teacher). A good example of a simulation exercise is "The Arab-Israeli Conflict," a character-playing conference where the students are asked to play various political figures involved in the current Arab-Israeli discussions. Started back in 1974, this simulation exercise was first "played" by political science undergraduates face-to-face in the classroom. The computer conference system currently used in the exercises (called "CONFER II" or, simply, "CONFER") was developed in 1975 and the two were combined in 1982. Since that time, the exercise has moved from the college to the high school level (using computer networking), so that high school students perform the character playing and college students participate as their advisors. Another example of a simulation exercise is the "U.S. Constitutional Convention" exercise where "delegates" from throughout American history attend a computer-based "convention" set in the "near future" to discuss issues surrounding the development of the Constitution and actually write a new Constitution.

The second type of ICS exercise is the "communications" exercise which consists of using the computer conference environment as a "communications tool." The "International Poetry Guild" is a good example of a communications exercise. In the Poetry Guild, each participating school is expected to produce a poetry journal as well as contribute to the other poetry journals of the other participating schools. Since each school must contribute, dialogue among the schools during the development of each journal is crucial and, ultimately, educationally valuable. Thus, the Poetry Guild brings together a broader range of ideas and types of poetic expression. Another example of a communications exercise is the new "Earth Odysseys" exercise. Starting in February, 1991, a four month trip was to be undertaken beginning in Europe and crossing the Sahara Desert to sub-Sahara Africa. The participants included ICS staff, teachers from the ICS network, two college students, and one high school student. The goal of the exercise was to stay in continuous contact with participating schools via some form of telecommunications. Thus, high school and middle school students would not only "track" the travellers, but also engage in their own investigations about topics related to the ones under investigation by those on the trip. Unfortunately, three weeks before the beginning of the trip, the Persian Gulf war broke out. The trip has since been re-routed to Eastern Europe. The exercise should continue in subsequent years through additional trips, supplemented by the transcripts and video tapes of previous trips and discussions.

The third type of exercise combines simulations with non-simulation communications, namely a kind of panel discussion among "experts." There is only one current example of this type exercise: the "Space Forum," in which students are expected to play "characters" involved in a discussion about the future of space exploration and related issues. In addition, they are asked to communicate, in a separate conference, with a panel of scholars which include university professors and professionals. There is a mutually supportive, interactive, and dynamic relationship between these two facets of the exercise.

The final type of exercise is the "Combination of Simulations and Case Studies", exemplified by the "Diverse Perspectives on Education" exercise (see Bair and Anderson, "Diverse Perspectives on Education: Connecting Theory and Practice in Teacher Education," 1991, in this publication). In this exercise, undergraduate students are divided into two groups. In one group, students are asked to play "characters" or "consultants" while the other students are expected to imagine themselves as "teachers" who must respond to a set of case studies. The consultants examine the teachers' responses to the case studies and dialogue with the teachers over the various issues presented in the case studies. Thus, the exercise involves "role playing," "character playing," and communications, all within the context provided by a series of classroom case studies.

The common denominator of all the ICS exercises is the computer conference system called "CONFER II" (TM) or, simply, "CONFER." Developed by Bob Parnes at the University of Michigan, "CONFER" is a combination of a "computer bulletin board" (which consists of general discussion "items" followed by participant "responses") and an electronic mail system (which consists of personal messages between participants). This computer conference system provides a versatile structure for many different types of discussions in all the ICS exercises.

Discussion

The ICS program combines many of the advantages of "distance" and "cooperative" learning. Ray Winders identifies several advantages to distance learning, especially computer based conferencing: 1) freedom from immediate time constraints for the student (i.e.,participants can often choose when and to what degree they will participate at any given time); 2) increased flexibility and availability of options (a large computer-based program like ICS can provide more types of learning approaches than would be easily developed at a smaller school or organization); and 3) service to students who would not otherwise receive this type of exposure (e.g., disadvantaged or handicapped students). (Winders, 1988, pp. 82-83). Another obvious advantage is that computer networking can bring together diverse voices which could not otherwise be included in a single discussion.

Because of these advantages, ICS has been a positive influence on very diverse participants and their schools. In general, there are four principal areas of educational enrichment within the ICS exercises:

1) enhancement of student learning;
2) development of teacher skills;
3) curricular development;
4) linking K-12 schools to higher education institutions.

Enhancement of Student Learning

The enhancement of student learning falls into several categories: 1) exposure to additional curricular content; 2) development of several "process" goals, including developing a personal pedagogic "creed," interacting with others through dialogue and discussion, developing an openness to diverse perspectives, consensus building, and cooperative learning (see Bair and Anderson, "Diverse Perspectives on Education: Connecting Theory and Practice in Teacher Education," 1991, in this publication); 3) enhancement of formal *and* informal learning; 4) establishing the complex nature of societal issues; 5) developing the skills for stable as well as fluid inquiry; 6) strengthening communication skills; and 7) computer literacy (or, at least, conquering computer phobia). The last five of these deserve additional discussion.

An important problem in education is how to create formal educational structures which enhance formal *and* informal learning. ICS does enhance informal learning by challenging the traditional classroom structure as well as the traditional teacher-student relationship. Since the distinction between teacher and student is redefined, the learning experience becomes much more like a two-way dialogue. After studying the effects of one particular computer conferencing system, Shoshana Zuboff pointed out that the quality of interactions is radically different within a computer conferencing medium: "Knowledge displayed itself as a collective resource; nonhierarchical bonds were strengthened; individuals were augmented by their participation in group life; work and play, productivity and learning, seemed ever more inseparable." (Zuboff, 1984, p.386).

Another important lesson or goal of the ICS exercises is that there no "solutions" to the "problems" identified within the exercises. In other words, these exercises are not games in the sense that there are either winners or losers or resolutions. The students are expected to "problematize" (identify new questions) rather than simply "problem solve."

Many of the ICS exercises are also designed to develop the skills of both stable inquiry (i.e., when the students are given specific directions as to how to approach a problem) and fluid inquiry (when students are encouraged to question and expand their methods of resolving problems as well as redefine the problems themselves).

Students also are given the opportunity to improve their communications skills. In particular, there is considerable anecdotal evidence that their writing skills are often dramatically improved. This is largely due to the fact that they must communicate with other participants who do not share their particular social or educational context. Thus, they cannot simply say, "well, you know what I mean". The students are obliged to logically establish their arguments and clearly express them to the other participants.

Finally, computer literacy is one of the most important initial motivations for many of the participants in ICS. In the last several years, "computer literacy" has become an issue of increasing importance. However, Shoshana Zuboff offers a word of warning about too much reliance on a limited view of computer literacy: "It's a terrible error to think that what's crucial for the future is people becoming 'computer literate.' That's just nonsense. I think it's important to demystify the computer and to understand that for children and students to be computer literate does not require that they know about programming or designing systems. Computer literacy means knowing how to look for information, how to gain access to it, and how to do something interesting with it when you've got it. One should have a sense of mastery about how to use the computer, but what one really needs is the ability to create meaning from abstraction, to create meaning from text." (Zuboff, in Emmons, 1988, p. 58) Thus, literacy cannot simply mean the transmission of knowledge or even the ability to communicate. It must also involve critical thinking and the other important "process" skills listed above. ICS effectively combines all these elements.

Teacher Development

Teacher development occurs in two ways. First, teachers are allowed to interact with other teachers and gain additional insights and perspectives on their teaching. Second, teachers develop skills which are normally associated with the skills of "lead" or "expert" teachers (self-directing, creative, etc.). In fact, we have found that the effect of ICS participation has been as great on the teachers/mentors as on the students. The following comment by an undergraduate mentor of the Poetry Guild captures the essence of the "teacher's" perspective, or at least that of one of the university student/mentors:

"Having worked for ICS for two semesters as a Guild Mentor for the ICS Poetry Guild exercise, I have come to two conclusions. Not only is the Guild a valuable learning experience for middle to high school age students, it is also a valuable learning experience for the student acting as Guild Mentor. Finding my role pleasantly enhanced this last semester, I became responsible for teaching the participating students about poetry, its craft, its pleasures, and the professional role of the poet in today's society every day for six weeks. The experience has led me to an important understanding and appreciation of the role of the teacher in the classroom. It became necessary to prepare every day before sitting down at the computer to "teach," which is similar to the experience of teachers in schools everywhere. I found myself stimulated by the students' contributions and discussions, which helped my understanding of the "classroom." Furthermore, as a graduating senior who plans on earning a Master's degree in the next two years, I have gained a significant appreciation for the structure of education in general. Indeed, I have revised my concept of teaching, and will benefit from this experience in my future obligation as teacher of creative writing by including the same sort of information I passed along to these middle and high school students to the students in the college classroom. Thanks, ICS." (Goodman, 1991, p.8) Other comments from teachers have shown that the ICS program has influenced how teachers view the learning and teaching process to the extent that they have changed their pedagogical styles.

In addition, evaluation forms sent to teachers have revealed that most teachers did not feel that the enormity of the workload outweighed the benefits of the ICS exercise. Of the teachers who were still actively involved in ICS, approximately 85% either disagreed or strongly disagreed that the workload outweighed the benefits. However, the responses of the teachers who had *discontinued* using ICS is even more convincing. Of these teachers, 60% disagreed or strongly disagreed that the workload outweighed the benefits. Furthermore, "46% had an unqualified desire to return, 29% said that they 'thought they would return'; 17% expressed an interest in returning if they had improved access to computers, could be given more latitude to build their class around the exercise, or make some other accommodation that would make the effort less burdensome. Only seven out of the 95 teachers could be interpreted in any way as having 'gone away' based on their dissatisfaction with the exercise." (Goodman, 1991, p. 12)

One final effect of the ICS program on teachers is that it enhances their teaching outside of the ICS program: "it is not unusual for teachers to report that one of the greatest benefits of ICS is that it rejuvenates their teaching. Perhaps it is being 'in the presence of' other dynamic, dedicated teachers; perhaps it is a matter of being involved in something that is 'larger' than one's own classroom; perhaps it is simply a matter of the exercises not being boring." (Goodman, 1991, p. 16) This is certainly a very gratifying aspect of the ICS program.

Curricular Development

As a supplementary part of the school's curriculum, ICS not only provides additional curricular content and exposure, but it also provides additional input into development of new curricular areas, directions, and approaches. An example of the former situation is one school where the "U.S. Constitutional Convention" simulation is the foundation for five elective courses in Constitutional History. An example of the latter is another school whose motivation for participation in the Earth Odysseys exercise is to develop curricular areas which are interdisciplinary in nature. The Earth Odysseys exercise represents an excellent forum for this since the participants can ask questions of the travellers as they are investigating a particular country; this is a context which readily encourages and integrates interdisciplinary questions, such as those addressing the areas of history, culture, and environment.

Connection Between K-12 and Universities

Finally, ICS provides an important connection between the K-12 system and the university environment. This connection is established principally through the efforts of undergraduate students who act as "mentors" to the secondary school student-participants. This connection benefits both of these groups, since the secondary school teachers and students receive the advice and direction of undergraduates who are specializing in relevant areas of study, whereas the undergraduates benefit from the experience of being in a teacher's role. Another type of connection between the university and the secondary schools occurs within the "Space Forum." In this exercise, the student-participants interact with a panel of experts, including university researchers and scientists. Thus, the students receive the direct input and expertise of the experts, and, conversely, the university receives a "reality check" on its own views and agendas. This dynamically interactive connection between "theory" and "practice" is an important, though often neglected, facet of education. A final connection between the secondary school and the university occurs within the "Diverse Perspectives" exercise. In this exercise, undergraduate teacher education students are asked to respond to classroom case studies as well as justify their decisions to a group of participants playing "consultants" who are chosen from a diverse group of educational scholars. In this way, the students must develop the ability to connect the theoretical frameworks that they study in their university courses with "real world" types of situations and decisions. Hopefully, they will carry these skills into their teaching experiences. Moreover, the "Diverse Perspectives" exercise represents a potentially important "feedback" mechanism for the other ICS exercises. Since Diverse Perspectives involves future teachers, these participants will probably tend to take advantage of the other ICS exercises once they begin teaching, thus widening the "web" of involvement in ICS and, consequently, greatly enriching the diversity and effectiveness of the dialogues in the entire ICS structure.

Conclusion

ICS is a continually evolving entity. This is an aspect of the program which cannot be overemphasized. However, in spite of its success, there are still some significant difficulties that we are attempting to address. For example, the "Space Forum" is an exercise which enjoyed relative success in its first year, and although it is very similar to the relatively stable and long-lived "Arab-Israeli Conflict", it is not enjoying high levels of continued participation. This may be due to the particular "mentors" or "experts" involved, the manner in which it was promoted to the schools, or the current relatively low levels of interest in issues involving space exploration. However, the fact that we do not have a clear explanation why certain exercises are successful whereas others are not indicates that the unique nature of the computer dialogue and the way it is incorporated into ICS is very complex and we still do not fully appreciate all of its dynamics. Another problem with the ICS program is that we have found that the teachers who would benefit the most from ICS, typically those teachers who follow traditional teaching methods, are not the teachers who are participating in ICS. We would like to find ways of recruiting these teachers.

Overall, we are now recognizing the incredible diversity of motivations of the ICS participants. In order to address the changing goals and needs of the participants, we are continually attempting to modify and improve the existing exercises as well as develop new ones. The program is called "*Interactive* Communications and Simulations," not only because of the interactive nature of the computer discussions, but also because we are continually trying to modify the exercises to meet the changing needs of our participants. This involves an ongoing process of experimenting with new approaches suggested or inspired by past and current participants. As the network of participating schools expands, the richness and value of the exercises also increases along with the identification of new needs and issues.

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Anchored Instruction in the Educational Uses of Telecommunications

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The educational use of telecommunications is in its infancy. Only recently have national and international efforts begun to take advantage of this technology to bridge social, cultural, and geographical boundaries. Primary and secondary school teachers have begun to experiment with the many ways in which telecommunications can enhance classroom instruction, and these teachers will play an important part in creating the future role for telecommunications in education. Schools of education are thus challenged to begin training teachers who can be leaders in the development of instructional uses for telecommunications. Anchored instruction provides a framework for preparing teachers to use telecommunications technology to solve realistic problems while they acquire skills with the new technology.

Primary and secondary schools are beginning to tap the power of telecommunications in the classroom. Classrooms around the world are being linked together to share cultural information, to collect data on global issues (such as acid rain and deforestation), to engage in cooperative group problem solving, and to simply exchange messages between penpals. KIDS-91 (see Note 1) is an exemplary project attempting to get as many children as possible involved in a global dialog during the Spring of 1991. Any student with access to Bitnet, Internet or other selected networks can participate in KIDS-91. Students on Bitnet and Internet can also find a penpal or make contact with other schools through KIDSNET (see Note 2). Seventy schools from 22 countries, encompassing Europe, North and South America, and the Pacific Rim, are connected through Apple Global Education (Engel, 1990). These and many other efforts have demonstrated some of the power of telecommunications in the K-12 classroom, and represent a challenge to schools of education to prepare teachers to be active participants in taking advantage of this new instructional tool.

Theoretical Background

When students learn factual material or procedures for using technology from a didactic lecture, they often only recall the information for the test and then promptly forget it. Just as often, students, when asked, cannot use factual knowledge they have acquired to solve real-world problems. This is what Whitehead (1929) has called "inert knowledge." Recent educational research suggests that "situating" instruction in realistic contexts can combat the problem of inert knowledge (e.g. Brown, Collins, & Duguid, 1989; Lave, 1988; Cognition and Technology Group at Vanderbilt, 1990). Situating cognition in context enhances learning by adding *WHY* the information is useful which is provided by the context. For example, in math class the concept of logarithms, while learnable, may seem quite unnecessary and therefore is often not remembered. But the concept may be easily remembered if learned in the proper context. For instance, when Newton was multiplying very large numbers to determine the distance to stars each night, logarithms' ability to change multiplication into addition solved a big problem (saving hours), and he remembered the idea without asking why he had to learn it. Shoenfeld (1988) suggests, at least for mathematics, that the only meaningful measure of learning is the ability to apply knowledge correctly in appropriate problem-solving situations. Shoenfeld contends that mathematics is a verb (something you do) as opposed to a noun (something you master). Research on situated cognition and Anchored Instruction suggests that the need to utilize knowledge in real situations goes beyond mathematics, and that instruction in all subjects, including the use of technology, could be improved if done using meaningful contexts.

Research on situated cognition highlights the need to use *realistic* situations in the classroom. Extending the ideas of situated cognition, the Cognition and Technology Group at Vanderbilt (1990) suggests that real situations can be brought into the classroom as either isolated cases (microworlds or microcontexts) or complex problem spaces capable of study from multiple perspectives (macrocontexts). Anchored Instruction involves using a realistic *macrocontext* across the curriculum. By using a macrocontext, communication across topics and an understanding of the relationships among disciplines is facilitated.

The student's role in Anchored Instruction is to be an *active* problem solver. Traditional instruction is often one-way, involving the transfer of information from teacher to student (e.g., Bruffee, 1982; Holmberg, 1983; McCroskey & Andersen, 1976; Stanford & Roark, 1974). Ideally, in Anchored Instruction students are more engaged in instruction and involved in a two-way exchange of information. Research has shown that even minimal engagement of the student in the learning situation can lead to improved recall of information (Anderson, Goldberg, & Hidde, 1971; Slamecka & Graf, 1978; Whittrock, 1978) — the "generation effect." When students generate all or part of the material to be learned themselves, the information is recalled more accurately and for a longer time. This is important, since expert problem solvers often use memory for previously worked problems to solve new problems that are similar— what has been described as "forward chaining" (Chase & Simon, 1973). Using generative learning techniques, then, can enable students to experience and adopt the forward chaining process often used by experts.

Anchored Instruction also involves teaching students how to wisely choose when to use certain technology to assist in problem solving, or in the present case, to aid instruction. A knowledge of how to wisely choose among various information sources has been described by Pea (1988). Unlike the conventional view in which intelligence is seen as being a fixed property of an individual, Pea (1988) has described intelligence as being "distributed" across people, places, and even codified into books, notes, and computers. When viewed this way, intelligence involves more than a knowledge of facts. Intelligence now includes how to access and retrieve knowledge, when and how to rely on the alternative sources, and how to manage and intelligently take advantage of information throughout the environment. By providing instruction in context, anchored instruction can facilitate the development of "distributed intelligence" as teachers learn about new sources for information made available through telecommunications and how to use technology to manage these new resources.

Project Description

In an attempt to situate instruction on the educational use of telecommunications, a series of four realistic scenarios were developed. Each scenario, presented as a short textual description (see Appendix), represented a context for anchoring instruction in a real-time collaborative effort. Graduate Education students from the two participating universities, the University of Connecticut and the University of Hawaii, self-selected into groups of four, two from each institution. Their task was to prepare a written response to the problem presented in the scenario. In order to accomplish this, students would have to collaborate using Bitnet. Collaboration would involve sending e-mail messages, uploading and downloading drafts of the report, and locating relevant information from listservers and other sources available on-line.

Four weeks were assigned in the middle of the semester to complete the project. Each group was required to address all the elements of their scenario in a written report that represented an equal contribution by all the members of the group, and that represented a consensus of the group. Each report was required to contain a title page, an abstract or executive summary, a statement of purpose, a list of the required hardware and software, a statement of the training required, and a budget (prepared as a spreadsheet).

Discussion

Ideally, the scenarios used to anchor instruction should be as realistic and complete as possible. Video, especially on videodisc with its random access capabilities, has proven to provide a more complete presentation of the context and setting for problem solving (see Cognition and Technology Group at Vanderbilt, 1990; Young, Van Haneghan, Barron, Williams, Vye, & Bransford, 1989). Providing the scenario through video represents a potential for expanding this project in the future.

As implemented, this project was anchored in the real world task of collaborating with fellow students *using* telecommunications. We believe the use of a real world context will greatly enhance not only the recall of information about telecommunications, but also the usefulness of the recalled information. By learning this information in context, it should be more available for solving problems (i.e. designing meaningful classroom activities)— reducing the problem of inert knowledge (Whitehead, 1929). Anchoring instruction should also enable students to better select when telecommunications projects will be most effective compared to more traditional activities; that is, the student's "distributed intelligence" will be enhanced.

As the implementation of this project began, an issue of equating the expertise and numbers in the groups at each site arose. While one site had an enrollment of 15 students, the other site had fewer than 5. The solution to equating numbers came by recruiting students in other technology-related courses who could benefit by participating in the project. Expertise across groups was not equated. Instead, we opted to allow groups to self-select. Since students were not in direct competition on this project, we encouraged more expert students to assist any group when called on to do so.

The teacher's role in this project is designed to change quickly from "giver of information" to more the role of coach or mentor. Teaching should become a role of giving advice as to possible technology issues to consider, or potential sources of relevant information. Advice should become more frequent than instruction. This new role of the instructor requires a change in the mindset of the instructor that may be difficult for some who are more comfortable with a traditional role. Therefore, it is suggested that when adopting similar methods, teaching techniques as well as the instructional content should be considered. The instructor should be prepared to withhold some judgments as to the correct solution in favor of pointing the way for students to develop and amend their own, or their group's, solution. A change in the role of the teacher is an essential component of the anchored instruction approach.

In summary, this project was designed to anchor instruction in the instructional uses of telecommunications technology through the use of four scenarios that provided a context for solving realistic problems. Students worked in groups across two higher education campus sites to cooperatively create consensus solutions to realistic problems. Students were encouraged to use technology to communicate between groups and to search for relevant information for problem-solving. Thus students learned both *about* and *with* telecommunications technology. An important component of the implementation was the changed role of the instructor from giver-of-information to coach and mentor. Future goals of this project involve constructing video or videodisc-based scenarios that more completely portray the contexts for problem solving.

Notes

1. KIDS-91 is sponsored by Televerket, a Norwegian telecommunications company, with information available through Internet (LISTSERV@VM1.NODAK.EDU), Bitnet (LISTSERV@NDSUVM1) or from Jonn Ord on SciNet (JONNO@ONTMOH.UUCP).

2. KIDSNET is an electronic list designed by Robert Carlitz (RDC@PITTVMS). To join send a subscribe message to JOINKIDS@PITTVMS.

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Appendix: Problem Solving Scenarios

Group 1: K-12 Education

Ms. Needles and Mr. Haystack teach middle school math and science, respectively, at a large public consolidated middle school, Reagan Middle School, located in the downtown area of a moderate sized city. Ms. Needles has just taken a course about computers last summer at the local university. Mr. Haystack does not have any computer experience, but is willing to learn. They have 28 students each in two different classrooms. Both teachers' classrooms have one computer (Ms. Needles has a Mac Classic and Mr. Haystack as a PS-2 Model 50X), and there is a lab of 15 Mac II machines that must be scheduled separately, down the hall. The school has just received a $15,000 grant and 4 free modems from a private telecommunications company with the stipulation that the money be used to creatively introduce the use of telecommunications into the middle school curriculum. They must make recommendations to the director of the school, who will take their recommendation to the school's Board of Directors for approval. In writing your version of their recommendation, address two major issues: 1) What kinds of equipment, software, and telecommunications services should they recommend for student and teacher use, and 2) What should be the curricular objectives for using telecommunication?

Be sure to give specific examples so the director and board members understand how you intend to implement your proposed program.

Group 2: Higher Education

Krakow Community College provides training in a wide variety of technical and career fields. Mr. Woods (teaches COBOL), Ms. Johnson (teaches math & statistics), & Ms. Pio (teaches electronics), have been designated by Ms. Leadbetter (the director) to serve on a committee charged with recommending to her how telecommunications can be integrated into the training that the school provides. The school has designated $7500 to be allocated based on the committee's recommendations. The majority of classes are taught in the evening and include courses on computer technology, electronics, medical career preparation, and business education. The college has a large mainframe facility as well as 2 microcomputer labs, one Mac based and the other IBM PS-2 Model 30 based. There is also one classroom on campus that has been adapted for multimedia presentations that includes a modem connection to a Mac IIci workstation. Take on the task of this committee and write the recommendation to the director.

Be sure to address faculty training, access, budget concerns, security, as well as the types of services to which the college should subscribe, e.g. Bitnet, NSFnet, Internet, CompuServe, Dialog, etc., and the areas or courses you would target for initial implementation of telecommunications use.

Group 3: Government/ Business/ Industry Training

Kowabunga, Inc., our nation's 17th largest insurance company, experiences frequent turnover in it's claims investigation department: average career length in that department is about 4 years. Claims investigators are those folks you have to deal with when you've had an accident and want your insurance company to send you a check. They must check your coverage policy, fill out forms, interview all involved with the claim to determine who is responsible and to what extent, and then approve appropriate payments by Kowabunga. Kowabunga runs four (4) training center scattered throughout the US: 1 in the northeast, 1 in the south, 1 in the midwest, and 1 in California. Yet all their claims executive are located at the corporate headquarters in Nome, Alaska (for tax reasons, apparently). As director of training, Ms Goodbaudy has often advocated the use of telecommunications. Now her boss, an executive VP, has asked her to write a proposal detailing how telecommunication might enhance the quality and efficiency of training provided by the company. Her boss has indicated that up to $25,000 could be made available on the merits of the proposal. Take on Ms Goodbaudy's task and develop her proposal.

Group 4: Magnet School

A small suburban school system has decided to create a magnet high school to encourage their best students and teachers to achieve excellence in education. The school system has placed no constraints on the physical design or the instructional design. Class may be organized around interest areas, or projects. Students may not meet in traditional classes at all, but rather meet briefly as a group and spend the rest of the day working in small group with a faculty advisor. The only decision has been to make the Theme of the school "flight." In their vision, the school system imagines students investigating the physics of flight, engineering and building a plane, and being involved in space flights through NASA. They would like the activities to reach across the curriculum, from history and language arts, to drama, art, math, and science. Your group of 4 has been selected (based on their expertise) to advice this project on the role that telecommunications can serve in this new setting. They have asked that you develop a specific scenario (or vision) of how students would use telecommunications to enhance their integrated curriculum, also to recommend the hardware, software, and online services (and associated costs) that would be required. Their budget is not unlimited and you have been encouraged to keep your initial budget under $20,000, but yearly ongoing costs are the scariest to them, and should be kept "reasonable."

Prepare your recommendation to the school system.

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Using Computer Communication To Enhance Teacher Education

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The education enterprise has long been plagued by fragmentation in its attempt to bring the collective intelligence of its many constituents to bear upon mutual problems—the preparation and nurturing of a teacher, improving the quality of life and learning in the schools, and learner centered faculty, staff and organizational development—to name a few. Numbers of solutions addressing aspects of these problems have been attempted with varying degrees of success. But still, barriers persist—barriers of the mind, organization, time, and space.

On occasion, new applications of technology appear that seem to offer alternative approaches to these problems. The purpose of this paper is to discuss the use of one such technology—computer mediated communication, specifically computer conferencing, in addressing some of these problems. First, we will describe the technology we are using. Second, we will elaborate on some of the problems that seem to lend themselves to the use of this technology. Third, we will discuss selected situations where we have employed this technology and relate some of our findings. And finally, we will offer some observations on implementing and sustaining the use of this technology in an educational organization.

Computer Conferencing

Technological developments in recent years have resulted in major cost reductions, and consequently, increasing availability of computers. With increased availability has come increased comfort with and use of the technology by individuals of all ages and occupations. The concomitant expansion of national and international communication networks has established an infrastructure that can link, through computers, the most remote location to resources heretofore inaccessible.

The technology of computer conferencing, existent for nearly thirty years, has only recently come into significant use due to the increased availability of computers and networks (Hiltz & Turoff, 1978; Mason & Kaye, 1989). While computer conferencing enables the private exchange of information electronically between individuals, its more important use is to facilitate the discussion and work of groups. It also enables geographically dispersed individuals to communicate at their own convenience. Each computer must be equipped with a modem and software to enable communication over the telephone lines. A computer so equipped can potentially be used for communication with anyone else similarly equipped locally or internationally. A central host computer, linked to the individuals by communications networks, stores and manages the interchange of communication. This technology seems to offer opportunities to address educational problem solving in unique ways.

Addressing Educational Problems

The intellectual and social structures that have grown up to give form to solutions for educational problems have become common place. Not that the common place means passe, only that we have become used to bringing familiar frames of reference, and therefore, solutions to bear as new problems manifest themselves (Waggoner, in press). For example, when confronted with a new issue or problem, we often resort to the same approach (e.g. forming a task force). The task force may convene meetings, hold hearings, receive selected expert opinions, and publish their findings and recommendations. In response to another emerging concern, we might organize a workshop or institute to elucidate the perceived need and present some alternative solutions. In approaches like these, we have attempted to make the best of available resources by using familiar forms to organize and deploy resources. As useful as these forms have been on occasion, they fall short of making optimum use of the collective intelligence and wisdom available to us. Improvement in the quality of and access to new communications technologies, like computer conferencing, offer opportunities to invent new frames of reference and new approaches. As a consequence, we can begin to break down some of the barriers that have grown up, albeit inadvertently, to make us less productive in exploiting the collective intelligence and wisdom available to us for problem solving.

Beginning at The University of Michigan in the early 1980s and continuing now at the University of Northern Iowa, we have been working to apply this technology toward the end of creating new frames of reference for the improvement of educational practice. At the University of Northern Iowa, we have begun to systematically create and nurture networks of learners and practitioners around the state from the elementary through the postsecondary levels. Central to facilitating the interaction of this network is computer conferencing. These networks are becoming an added dimension of the College's multifaceted mission, contributing to the development of a new frame of reference for education problem solving. In this new frame, there is the opportunity for breaking down the unproductive distinctions among teachers and learners, and for drawing upon the rich and varied perspectives of all participants in the discussions. It is also an opportunity to include practitioners as full partners in improving teacher education. A few examples of how these networks operate should illustrate what we are trying to accomplish.

Examples of Technology Use

There are three areas where pilot studies have been undertaken; other serendipitous applications of special interest will be mentioned also. First is the use of the network for communication among the members of the Office of Student Field Experiences—those individuals who work directly with student teachers during their intensive clinical experience of student teaching. Second is the use among the student teachers. And third is the use with the first year teachers.

Office of Student Field Experience

Faculty and staff of the Office of Student Field Experiences are located in ten locations across the State of Iowa; from those locations they supervise over three hundred student teachers each year. In each location there is a UNI faculty member who works closely with a clinical supervisor. While this clinical supervisor is from the local school district, half of their salary is paid by the university and for that portion of their time they are part of the clinical supervision team. Additionally, in each of these locations, there have been identified master teachers who form a cadre that participate in various aspects of teacher education depending upon their expertise. Taken as a whole across the state, this group represents a rich resource of intelligence and experience. The potential power of this group is enhanced by their being linked together through the computer conferencing network. Prior to this group being formed, the ten faculty coordinators would meet face to face on campus once a month to discuss matters relating to teacher preparation. Now they are in almost daily contact through the network. This has had multiple effects. First, it has increased the sense of connectedness among the faculty coordinators—both among themselves and with the campus colleagues. Second, it has improved the productivity of the monthly face to face meetings. With the regular contact in between meetings, more work can be accomplished so that face to face meetings concentrate on matters that can best be handled in that medium. Further, the work of the group is enriched by the addition of the clinical supervisors and now the cadre members. The network is a vehicle for forging relationships between the academy and the practitioner, a connection vitally important for a College of Education.

Student Teachers

The student teaching experience is an intense and crucial, formative experience. It is a time when all the preparatory training and experience is brought to bear in an actual classroom experience of significant duration. In a conventional student teaching situation, the student teacher has access to the cooperating teacher in whose classroom this experience is taking place, the supervising faculty member from the university, and their peers in weekly face to face seminars. The addition of the computer conferencing networks to this experience accomplishes several important things. First, it expands the resource base for the student teacher. In addition to the available resources mentioned above, the student can now have access to faculty coordinators, clinical supervisors, and peers across the state. Furthermore, the student may now have access to resource people back on campus including professors in the content areas or methods areas, or library and media staff. In instances this year, we have had student discussions taking place on the system with library resource people following these discussions. On occasion, the resource people would enter the discussion, noting that there was material available in the library for a problem the student seemed to be having. The student would acknowledge that that would be helpful and the material was mailed immediately on loan. Similar offers of counsel from supervisors and peers represent significant enhancement of resources during this critical training period.

Second, the student has an alternative and supplementary communication medium. Given peoples schedules and relative comfort levels with face to face communication, this network represents another way to connect with those who can be of help during the student teaching experience (Hiltz, 1986). These connections become additional support groups, mechanisms that have proven to be helpful in intensive clinical experiences. There have been a great number of late night conversations over the networks where classroom situations and teaching strategies have been debriefed, apprehensions have been allayed, and hunches have been affirmed. All these things, we believe, contribute to the strengthening of the student teaching experience. Similar problems surface in the experience of the first year teacher.

First Year Teachers

The literature on "the induction year" is replete with references to the high attrition rate experienced among first and second year teachers. These concerns have found their way into guidelines for conducting teacher education programs produced by the National Council for the Accreditation of Teacher Education (NCATE). They are concerned with the follow-up activities that colleges and universities plan for their newly inducted teachers. Our experience with the use of computer conferencing indicates a value that parallels that for the student teacher. The need to be in contact with someone who can be a resource, on multiple levels, is very important. The levels of resource range from peer commiseration for the hard times and peer celebration for the successes, to contact with a content or methods resource person about information on a topic or a particular approach or strategy. It appears that a very important use of this system is for discussion among peers for what has been called "moral support" in other circumstances. There are, of course, significant differences between the student teaching experience and having you own classroom with all the problems and opportunities that come with it. New teachers seem to take advantage of contact with others outside of their immediate school setting for this kind of support. It seems to enable them to perform more confidently in front of their own students and more experienced colleagues in the school.

Lessons Learned

Both authors of this paper have been fortunate for the past ten years to be in positions that have provided us with an opportunity to experiment with the use of computer conferencing in education. During that time we have developed a sort of "practical" wisdom, a sort of "do" and "don't" list concerning the implementation, use, and sustaining of computer conferencing. Some of this practical wisdom follows.

Have a Vision

For change to have a long life and to eventually become ingrained into the fabric of the organization, it must be a component of a vision "shared" by members of the organization. The vision cannot be that of a lone individual. With computer conferencing, that vision might consist of a large network of educators throughout a region or even the world being able to communicate in a cost-effective manner without barriers of time and space in the collective pursuit of solutions to real educational problems.

Focus on a Theme

Focus on a theme that helps define the vision and that can be communicated to others. For example, with computer conferencing the theme might be that of "collective intelligence" referred to earlier in this paper. This theme focuses on the value of computer conferencing in allowing the collective intelligence of all of the participants in the conference to be brought to bear on an important issue. Another theme might be the "knowledge base that exists in professional practice". Through the use of computer conferencing, we provide the mechanism for educational practitioners to bring the knowledge base they possess to bear on educational issues.

Address Real Educational Problems

Technology is, of course, neutral in the sense that a particular technology can be used for multiple purposes. What we "choose" to do with the technology is what makes a difference. For example, at the University of Northern Iowa we are concerned about the limited number of minority young people who are entering the teaching profession. UNI has, therefore, initiated an early identification program where minority youth as early as fifth and sixth grade work with school and university personnel to prepare them for a career in teaching. Through the use of computer conferencing these minority young people in various geographic locations around Iowa can be linked to each other and to the university in a cost-effective manner. Computer conferencing is seen, therefore, as an integral component of a system designed to achieve this important objective.

Design Structured Solutions

A structured solution is a comprehensive plan to structure the environment in such a way to achieve an important educational goal. As mentioned previously, the plan we are implementing at UNI to encourage minority youth to enter teaching is an example of such a structured solution to a key problem. An integral component of this structured solution to this problem is the use of computer conferencing to allow the various cohort groups to communicate with each other, for participants at different stages of the system from beginning teacher to fifth grade student to communicate, and for university and school personnel to be in constant communication with each other and with these students. Technology is not, then, a stand alone item but is part of a larger structured solution to a real educational problem. The use of computer conferencing in this context transcends individual effort and incorporates the use of technology squarely in the achievement of a broad institutional objective.

Take a Systems Perspective

Due to the complexity of promoting change within a highly complicated social system, it is little wonder that educators have not been very successful in creating integrated systems to achieve their objectives. The history of education in the United States provides many examples of the inability or unwillingness to take a systems perspective toward educational change. A systems perspective is, however, absolutely essential if change is to be successful. All component parts of the system must be in place for full implementation to occur.

Uneven Progress and Ambiguity

Regardless of how hard you try or how careful you are in planning, things will go wrong. Few things in life are rational and linear and this is especially true wh n attempting to introduce technology into complicated social environments. At times even the goal may seem to have lost its focus and circumstances become ambiguous. Temporary setbacks must be expected and continual reference made to the long-term vision discussed above.

Use Time To Your Advantage

Change is a process not an event. Change takes place over time and frequently over a long period of time. Accept this fact and plan for change to occur in stages that take time. Structure the solution, build the system, put the component pieces in place, and use time to your advantage.

Put Someone in Charge

Change does not occur by wishful thinking. If you want change to occur, you must have someone in charge of the effort. This seems especially true when dealing with technology. The change process requires a manager to direct it. In addition, for many people using technology can be a frightening experience. If the technology fails, they feel that they cannot fix it and they want help immediately.

Promoting Social Change

It is wise to remember that in using computer conferencing, a technological innovation, what we are really trying to bring about is social change. Technological change is not synonymous with social change. With computer conferencing, we are no longer constrained by barriers of time and space. People are provided an interactive mode of communication not previously available to them. Problem solving takes on a new dimension and the collective intelligence of various parties can be brought to bear on an immediate issue of concern. In these cases the technology has served its purpose in allowing change to occur in the nature of human interaction. That change in human interaction is social change.

Understanding the human dimension of technological change can help us appreciate how individuals might be affected by the change and how they might react to the change effort. It also helps us understand the larger social consequences of the change we are attempting.

Computer conferencing, then, provides an alternative to face-to-face communication; an alternative that holds great potential for engaging people in problem solving concerning real issues in education. We encourage its use in improving programs in teacher education.

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The Electronic Bulletin Board and Off-Campus Extension Courses

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Learning at a distance has taken several different forms. It often involves using television-based approaches to off-campus education. Distance learning doesn't necessarily need expensive or fancy equipment, it just needs to be instructionally sound. "Resource sharing is the key to economic viability of most distance education projects. This arrangement [offers] higher education opportunities to the student and new audiences to the college" (Heinich, Molenda, & Russell, 1989).

The Electronic Bulletin Board (EBB) has been used in situations as various as an undergraduate course in engineering and an off-campus doctoral course. Comments include, "All in all, the use of electronic mail resulted in a more efficient use of time and increased student/teacher interaction" (Welsch, 1982) and "We are encouraged that the students themselves strongly support the continued operation of the bulletin board. Both they and we remain optimistic that a significant new communicator tool is being forged" (Gardner & Tillman, 1986).

And as Meeks states "The ultimate goal of [the use of the Electronic Bulletin Board] is a simple one: getting an education without setting foot inside a classroom" (Meeks, 1987).

Computers as Communication Devices

Imagine a classroom with a very large blackboard. The instructor writes a problem/question on the board and leaves the room. Students can drop by, day or night, and provide a solution or response to the issue or to others' comments at their own pace. All the responses and comments along with the problem/question stay on the board at all times. Also imagine that each student could receive his/her own copy of this discussion and debate by simply pushing a button.

The Electronic Bulletin Board would be the "blackboard" upon which our class was to take place. Through use of a computer, the telephone line and our Electronic Bulletin Board, students were connected to classmates and professors.

Electronic Bulletin Board Class Organization

We decided to "work" with the teachers in their classrooms before or after school or during the lunch hour. Through three 7-hour class meetings (reduction by half of normal face-to-face contact) and use of the Electronic Bulletin Board we hoped to maintain critical benefits of personalized instruction while enhancing both pacing and enthusiasm that the teacher brought to her/his lessons.

Each student's home/school computer time was spent in:

1. Participating in an Electronic Bulletin Board seminar,
2. Composing responses to assigned lessons, readings and exercises,

3. Reading personalized feedback on lessons and questions already submitted to the teacher,
4. Participating in group projects.

Students were given several individual and group assignments. Some of the assignments had to be posted on the board for critique by others in the class. Students were also divided into several groups to work on group projects. Group leaders were responsible for collecting all the individual papers and assembling them into a complete project before posting it on the Board.

Student Evaluation

Student activities on the Board were fully documented. In addition, a questionnaire was designed and then administered to the students at the end of the semester for evaluation of the course. Students were assessed in several areas (e.g., learning skills, knowledge of computers and the Electronic Bulletin Board, group dynamics, etc.).

Learning on the Electronic Bulletin Board led to a more-or-less constant level of writing for "public" inspection. This led to a higher and more thorough engagement with the content than would normally attend participation in a graduate lecture- or seminar-version of the course. Students who were more frequent and effective Electronic Bulletin Board participants did far better, even when we made sure assignments were available and even given that there was more than twenty hours of face-to-face interaction with the instructor and classmates.

Suggestions

The following actions will be taken to improve computer-mediated course delivery:

1. Have students bring their workstation to a central location and train them so that they operate their Electronic Bulletin Board satellite station before they leave the training site.
2. Have students return one week later, with their equipment to practice more complicated actions such as uploading and downloading files.
3. Have a system that allows several students to simultaneously access the Board, thus easing scheduling problems.

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Continuing Education for Teachers Through Electronic Conferencing

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Introduction

Almost ten years have passed since teachers gained initial access to electronic mail and electronic conferencing utilities housed at colleges, universities, and research institutes. These initial projects were exploratory in nature, providing teachers with the opportunity to exchange information and teaching ideas (Katz, McSwiney, & Stroud, 1987). Some efforts sought to include students and teachers in curriculum activities, usually in science (Perry, 1984; Newman, 1987). Some institutions of higher education and research facilities have applied computer-based telecommunications to teacher education projects. These have included support services for student teachers (Sunal, Sunal, & Helfeldt, 1991) and neophytes doing practical training in schools (Bull, Harris, Lloyd, & Short, 1989) as well as continuing education projects for experienced secondary and elementary school educators (Kimmel, Kerr, & O'Shea, 1987).

A brief review of a number of these efforts reveals interesting commonalties worthy of further investigation. When projects that support pre-service teachers, student teachers, beginning teachers and veteran teachers are clustered by teacher experience, obstacles to further progress in supporting teachers' professional growth through electronic communications become noticeable, but opportunities become evident as well. In this paper we briefly review projects that fall in one of the aforementioned categories, noting the comments of investigators related to the success or shortcomings of their efforts. We then offer some thoughts as to the resolution of difficulties observed and some questions to be answered in the empirical studies that should follow.

Supporting Student Teachers Far From The Main Campus

The University of Northern Iowa (UNI) prepares teachers for all communities in the state of Iowa and many locations throughout the United States and beyond. Iowa is essentially a state of rural character, with small towns and municipalities serving as settings for practical teacher training. The College of Education has met the challenge of providing practical training experiences across all of Iowa through the establishment of ten regional student teaching centers, some as near to the home campus in Cedar Falls as Waterloo, others located quite far away in Council Bluffs and Fort Dodge. Each center has a full time faculty member of the College of Education in residence, as well as clinical supervisors who assist in supervising student teachers in their school settings.

Beginning in the Fall of 1988, the UNI embarked on a project intended to deepen its commitment to school/university relations through the establishment of Teacher Associates Cadre (Switzer, 1991). Teacher Associates

Cadre are cooperating teachers in community schools who are retained by the University in a long term commitment to teacher education. Each of the cadre are tied to one of the University's ten off-campus regional centers. While traditional modes of communication, including on-campus cadre conferences, have been implemented to keep professional communications open and active, computer conferencing and electronic mail have been added as an additional medium for linking student teachers, Teacher Associates Cadre, regional centers, and main campus faculty at Cedar Falls.

Electronic conferencing is supported by "Caucus" communications software first installed at the University of Michigan. "Caucus" is a high capacity facility housed on a mainframe computer and is well equipped to handle the volume of communications resulting from the placement of as many as seven hundred student teachers throughout all of Iowa in a given year. Each student teacher participating in the expanding telecommunications component of the UNI student teaching support program is provided with an IBM lap-top computer with modem. The $3,000 per month cost for telephone service to the computer housing "Caucus" at Cedar Falls attests to the volume of electronic mail and electronic conference activity taking place through the UNI program.

Project participants report that contributions by student teachers to public conferences on the "Caucus" system consist predominantly of classroom management, philosophical issues, and peer support. The sharing of lesson plans and other curriculum related materials takes place less frequently.

Electronic Telecommunications and a Five Year Teacher Education Program

While others have utilized educational technology to support student teaching in practical training settings situated far from the main campus of a college or university, the University of Virginia (UVa) utilizes telecommunications as part of a larger commitment to educational technology in its five year teacher education program (Bull, Harris, Lloyd and Short, 1989). Through a substantial gift from the IBM corporation, UVa has infused telecommunications and computing technologies in all facets of the prospective teacher's professional growth. As second year students at the University, these future teachers are instructed to use electronic mail and electronic conferencing in the preparation, editing, and submission of written work. As third year students, UVa future teachers learn to produce graphics and other teaching materials with computers. Fourth year students focus their efforts on the use of technology in content specific methods courses. In their last year, students are trained to use Teacher Link, the University's electronic telecommunications facility, during their school based practical training exercises.

Presently, over 400 teachers, including UVa teacher education program alumni, connect with each other through electronic mail and electronic conferencing - the communication facilities available through Teacher Link (Cooper, 1991). The involvement of project alumni and University faculty in Teacher Link activities provides for a richer curriculum resource than is typically found when neophyte teachers merely share classroom management problems. For instance, questions raised by students in their science classrooms are forwarded by teachers to University faculty and peers for full and accurate responses. Additionally, students in elementary school settings are prompted to ask questions of historical and fictional characters (including "Mr. Jefferson") they encounter in reading experiences. These characters are portrayed over Teacher Link by UVa faculty members and other adult participants on the system. The continuity of computer and telecommunications experiences made available to teachers in training at UVa over a period of several years should be viewed as a positive development in educational technology for teachers, worthy of emulation by other teacher training institutions.

Communications Support for Beginning Teacher Induction Programs

Some university faculty have focused their efforts on the retention and support of teachers after they have assumed full time teaching positions. In some cases, these full time teaching positions are paid teaching internships with course credit as a culminating exercise for a graduate level teacher preparation program. As such, paid teaching internships share features in common with contracted first year independent teaching and course requirements with university supervision commonly associated with student teaching. In other instances, faculty have begun to apply telecommunication technologies to support first year teachers in beginning teacher assistance programs now required in some states. When students take contracted teaching positions, they find their jobs where they are available. Typically, first year teachers are widely dispersed when compared with student teachers. Telecommunications technologies might provide a cheaper alternative to face-to-face visits, as well as a permanent record of interaction not easily accessible through telephone conversations.

Connecting First Year Teachers from a Graduate Program

Support for first year teachers from Harvard University through electronic mail and electronic conferencing was preceded by an earlier effort that sought to support inservice science teachers through a microcomputer based networking program called "Common Ground" (Hancock, 1985). This pioneering effort connected seventy-five science teachers in eastern Massachusetts with five science department heads, an experienced staff developer, a graduate student in teacher education, and four teacher moderators (Katz, McSwiney and Stroud, 1987). The intention of the project was to stimulate collegial exchange related to science teaching. The project coordinators noted some difficulties in sustaining high rates of communication.

Many project participants failed to overcome the obstacles associated with getting started in using a microcomputer, modem, and related software. Moreover, discussions that didn't fulfill any identified need failed to stimulate a consistent rate of new contributions."Readers" very often outnumbered "writers." When contributions are offered infrequently, people stop logging on when they see no new entries for several days. In 1987, Katherine Merseth, then Director of Teacher Education at Harvard University's Graduate School of Education, applied electronic mail and electronic conferencing through "Common Ground" to support beginning teachers who had completed Masters degrees in Education and had received teacher credentials. Thirty-eight teachers participated in the project along with two University faculty members, a teacher education program administrator, a graduate assistant (an experienced teacher), and invited experts (Merseth, 1990). It is interesting to note that contributions observed by Katz and McSwiney in their earlier effort with experienced science teachers (using the same system) were dramatically outnumbered by neophytes teachers observed by Merseth. Moreover, the public comments provided by the neophytes centered on philosophical issues involving teaching and schooling as well as problems involving classroom management and discipline. Few contributions were offered in the area of lesson planning or curriculum development. In spite of this, neophyte interest in "survival" concerns and philosophical issues sustained a rate of over 80 messages per week, of which 40% to 50% were private.

Others who would be interested in starting a teacher support program through electronic conferencing might consider a modest starting effort like that undertaken by Katherine Merseth. "Common Ground" is available for only $30.00 and can be run on an IBM XT with a hard disk drive or an equivalent machine. The entire communications utility including hardware plus software was stored in a closet at the Gutman Library at Harvard University.

Electronic Conferencing for Beginning Teachers in Texas

The state of Texas has been a leader in establishing beginning teacher assistance programs, yet the nation's second largest state in geographic area has approximately 1000 school districts, many of which are isolated in remote and lightly populated locations. With these conditions in mind, faculty of Sam Houston State University in Huntsville inaugurated project "First Class," an induction program for beginning teachers that matches electronic mail and electronic conferencing to more traditional support methods of mentoring and coaching (Merchant and Brown, 1991).

Through a contract with GTE corporation, the first year teachers and faculty of Sam Houston University have access to GTE's Electric Pages, a utility featuring electronic mail and electronic conferencing; as well as a toll free telephone line so that teacher participants would not be charged for the calls they made. As first year teachers began project activities, schools where they were employed agreed to provide a computer, time during the working day for the new teacher to communicate via the Electric Pages, and released time for training support. In return for these considerations, the project provides the school with a modem and software matched to its computer equipment. Project training services are also provided at no cost to the district.

Human resources that are made available to teacher inductees include access to a technology specialist (typically stationed at a regional Education Services Center), an on-site mentor selected by the school staff, a subject matter mentor, and University faculty. The electronic mail and electronic conferencing features of the project can make off-campus human resources available to teacher inductees on a regular basis. In one instance, a first year band director learned to coordinate band event scheduling with the help of a content mentor (another band director) located over one hundred miles away.

Beginning teachers are prompted to participate in telecommunications activities through the completion of weekly assignments that are sent to them over the Electric Pages. While an evaluation of the project's communications has yet to be conducted, faculty overseeing the project report that the frequency and kinds of public communications are similar to those observed at the UVa and UNI projects. Clearly, first year teachers prefer to plan lessons and curriculum through more traditional means, even when telecommunications facilities are made available to them.

Inservice Teacher Education for Veteran Teachers

In 1984, the Electronic Information and Exchange System (EIES) of the New Jersey Institute of Technology (NJIT) was applied to an in-service education program for veteran middle school and elementary level science teachers (O'Shea, Kimmel and Novemsky, 1990). The program consists of an expanded model of inservice education originally consisting of three parts: Saturday morning workshops held every six weeks during the academic year, electronic conferencing and electronic mail linking teachers between workshops, and visits to school sites of teachers to provide technical and political support (Kimmel, Kerr, and O'Shea, 1987).

During the Saturday morning workshops, fifteen to twenty teachers are provided with hands-on investigations related to a science theme they have selected for the academic year. Additionally, guest presentations are made by experts, and peer discussions of pedagogical strategies and curriculum sharing related to the year's theme take up much of the available time. Between workshops, teachers use EIES to share data gathered by students during investigations that the teachers first tried during the Saturday sessions. The project participants also use electronic mail and electronic conferencing to share their impressions of the teaching effectiveness of various curriculum materials, and to plan future Saturday sessions. Technical support during site visits involves the training of teachers to communicate with the computer equipment they have in their own schools. During these visits, efforts are made to meet with school administrators and supervisors to stress the value of the project for the teacher and students alike.

In the last three years we have added a fourth feature to the model, which is a culminating student symposium held at NJIT. During the Saturday sessions and EIES conferences, teachers plan for their students to meet one day in the spring in order to present their investigations related to the science theme selected for the year. Major projects undertaken by entire classes are conducted in brief, plenary sessions. Shorter investigations performed by a class or small group (such as a Science club) are presented as poster sessions. In poster sessions, students are expected to switch roles as both presenter and reporter of other students' activities. The findings of all students are recorded and taken back to schools by peers for further analysis and reflection.

During the first three years of our project, we found that teacher turnover in the group of fifteen to twenty veterans amounted to as much as thirty percent from any given year to the next. Since the symposia were added to the program, turnover in participants from year to year has been less than twenty percent. Teachers have reported that the symposium development and year long theme selection have made for a more rewarding over-all professional development effort.

Implications for Further Study

A casual review of the project descriptions provided above reveals some general tendencies:

- electronic communications between first year teachers tends to focus on "survival" needs;
- first year teachers and other neophytes like to discuss philosophical issues about teaching practice and their early experiences in schooling;
- when students are exposed to telecommunications and related computer technologies as part of a comprehensive and continuing teacher preparation program, use of the electronic communications facility broadens to include some student centered, curricular activities;
- veteran teachers persist with a professional development project supported by electronic telecommunications, when clear curriculum goals selected by the teacher participants and a planned event of value to teachers and students alike are included in the project.

As additional efforts are made to investigate the role electronic networking plays in the professional growth of teachers, empirical studies will be needed to identify the needs of teachers that can best be supported at various points in the professional life of the teacher. It appears that neophytes have certain needs filled through peer communications, while veterans can sustain their love for teaching through activities that expand their repertoire of instructional activities. Electronic conferencing and electronic mail can play an integral role in fulfilling teachers' needs if those needs are clearly identified by researchers working with these new communication modalities.

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Establishing a Peer Mentor Science Network

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The report of Virginia's Commission on the University of the 21st Century notes, "Teaching and learning throughout higher education should be re-examined to ensure that advanced computing and telecommunications equipment is used to increase the learning capacity of students and faculty contacts with students rather than to diminish them" (Commission on the University of the 21st Century, 1989, p. 4). The Virginia Department of Education is establishing a Public Education Network (Spagnolo, 1990). The initial specifications for this computing network were developed at a symposium jointly sponsored by the Virginia Educational Computing Association and the Virginia Department of Education (Bull, et al., 1989). The system will connect approximately 2,000 Virginia schools in 137 school districts to the existing national inter-university computer network, or *Internet*. The Internet in turn links tens of thousands of academic sites, commercial firms, and government agencies around the world.

A Public School Telecomputing Network

When the statewide system in Virginia is completed, a single seamless telecomputing network will link all Virginia schools from kindergarten through graduate school to the Internet (Bull, Hill, Guyre, & Sigmon, in press). To emphasize its use as an instrument of communication, the statewide network has been given the acronym of *Virginia's PEN*.

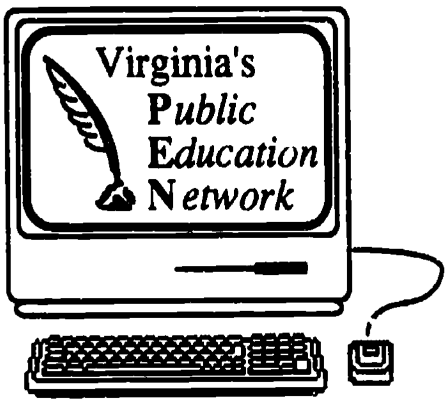

Figure 1: Virginia's PEN

The network has conferencing capabilities that potentially have great instructional value. Prior experience has indicated that in the absence of models, teachers often tend to use the network for emotionally supportive dialog rather than for structured instructional activities (Bull, Harris, Lloyd, & Short, 1989). While this type of peer support is valuable, support for direct instructional activities is equally important.

It is desirable to provide instructional activities on the computer conference as examples for teachers when they first join it. This gives new users an illustration of the types of instructional activities that are possible, and encourages them to contribute similar activities. Many of these activities may involve direct use of the network. For example, weather data can be collected with science sensors attached to the computer, and shared with classes in other locations via the network. Lesson plans and other activities that do not require use of the network can also be shared on a computer conference.

A number of pilot projects have been initiated to develop methods, materials, and training for the instructional use of Virginia's PEN. For example, the Consortium for Interactive Instruction in Norfolk is using the conferencing system for discussion and exchange of materials related to the Voyage of the Mimi. In another project, teachers working with the Governor's School for Science and Technology in Lynchburg are exchanging hypermedia projects developed by students with other classes across the state. On-going projects have also been initiated with a number of other countries such as Spain, England, Australia, and Finland.

The science mentor networking project is a pilot project designed to provide support for elementary and middle school science teachers through Virginia's PEN. The initiative is intended to seed the computer conference with on-going active interchanges which will serve as a magnet to attract other science teachers as they obtain network accounts. Working with facilitators at the university, networked science and mathematics activities are being developed and shared via a computer conference established for this purpose. Master teachers at the high school level are linked with middle school science teachers. Their on-going interactions are intended to facilitate the integration of the materials into day-to-day lessons, and lead to development and refinement of new activities.

The Need for Instructional Models

Recent standards established by the National Council of Teachers of Mathematics (NCTM) call for integration of technology into the instructional process. For example, the National Council of Teachers of Mathematics states that instruction should be based on "numerical and geometric experiences that capitalize on both calculator and computer technology" (NCTM, 1989, p. 180). In its 1989 Curriculum and Evaluation Standards for School Mathematics the Council notes, "The curriculum must give students opportunities to solve problems that require them to work cooperatively, to use technology, to address relevant and interesting mathematical ideas, and to experience the power and usefulness of mathematics" (NCTM, 1989, p. 75) A committee of the National Science Teachers Association is presently being established to formulate similar standards in science education.

In Virginia the Commonwealth has responded by taking steps to provide the requisite hardware required for infusion of technology into the instructional process. In 1989 the Virginia Department of Education adopted a six-year technology plan for Virginia's schools which establishes foundation levels of technologic support. The adopted plan states, "Each trained teacher should be provided with access to a microcomputer, printer, and LCD (or large monitor) projection system. Microcomputers are to be used for teacher productivity and as a *classroom teaching tool*" (Virginia Board of Education, 1989, p. 14). The plan also calls for provision of other technologies, such as videodisc players, in each elementary and secondary school building. During the 1988-89 biennium more than 6,000 computers were distributed among 133 school divisions through the Governor's technology initiative.

There is considerable evidence to indicate that provision of hardware alone does not automatically result in effective instructional integration of technology. For example, a survey of microcomputer-based laboratory (MBL) sensors distributed to middle-school science teachers in one school system found that they were virtually unused. Despite one training session in the use of the sensors, teachers felt ill-prepared to integrate them into day-to-day science instruction (L. McCullough, personal communication, November 21, 1990). They felt a need for on-going support to supplement the initial training. The support that teachers obtain from their mentors via the network may enable them to teach units of study that they would have felt hesitant to teach otherwise.

This reported instance is not an isolated case. In 1989, Helen Edens, of the Division of Media and Technology of the Virginia Department of Education, and Bruce Gansneder, a researcher in the Curry School of Education at the University of Virginia, completed a survey on use of instructional technologies in Virginia (Gansneder, 1989). The survey was based on information from approximately 1500 teachers from every area of Virginia. The results of the survey indicated that many secondary and elementary teachers do not use computers for instructional use even occasionally, despite the availability of hardware, as Figure 2 (next page) illustrates.

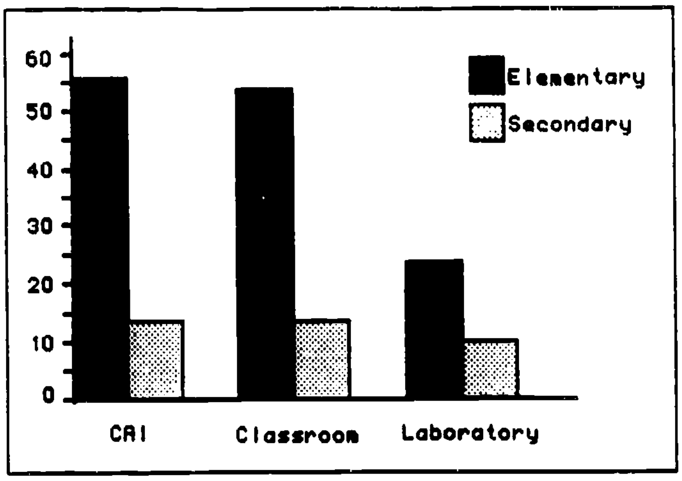

Figure 2: Percentage of Virginia teachers who use computers for computer assisted instruction (CAI), classroom use, and laboratory use.

The rapid ten-fold increases in power that have been occurring within the computing industry every few years have brought the hardware capabilities required to run sophisticated data acquisition and analysis programs within the reach of teachers in the 1990's. However, increases in hardware capacity have not always produced discernable changes in instructional methods. As the NCTM standards note, "access to ... technology is no guarantee that any student will become mathematically literate." (NCTM, 1989, p. 8)

A Peer Mentor Science Network

In addition to support for electronic mail, Virginia's PEN has a conferencing system based on USENET news groups. There are thousands of sites which participate in the USENET system, including most major universities, government agencies such as NASA, and commercial firms. Virginia's PEN extends this system to public schools in Virginia.

There are three types of news groups on Virginia's PEN: international, state, and local. More than 800 international discussion groups are available on the USENET system. These news groups are organized by categories, such as science, societies, computers, and recreation. Each category has subcategories. For example, listings under science include biology, chemistry, physics, mathematics, and space among other topics. A special category of news groups has been established for the public schools on Virginia's PEN distributed only to schools within Virginia. News groups in the Schools domain can be established for any instructional topic.

When new instructional technologies are introduced, teachers need on-going support as well as initial instruction. Virginia's Public Education Network (PEN) provides the technical capacity to offer this type of on-going support. It will allow teachers to share ideas, instructional techniques, and academic support. Without instructional models, the full potential of the network is unlikely to be realized however.

One model we are developing focuses on the physical sciences, and links high school physics teachers with science teachers in the middle schools. In the pilot, five high school teachers are each being paired with a middle school science teacher and two elementary teachers in their respective districts. Each high school teacher serves as a mentor to the three middle school and elementary teachers, suggesting instructional activities and uses of technology, and providing guidance.

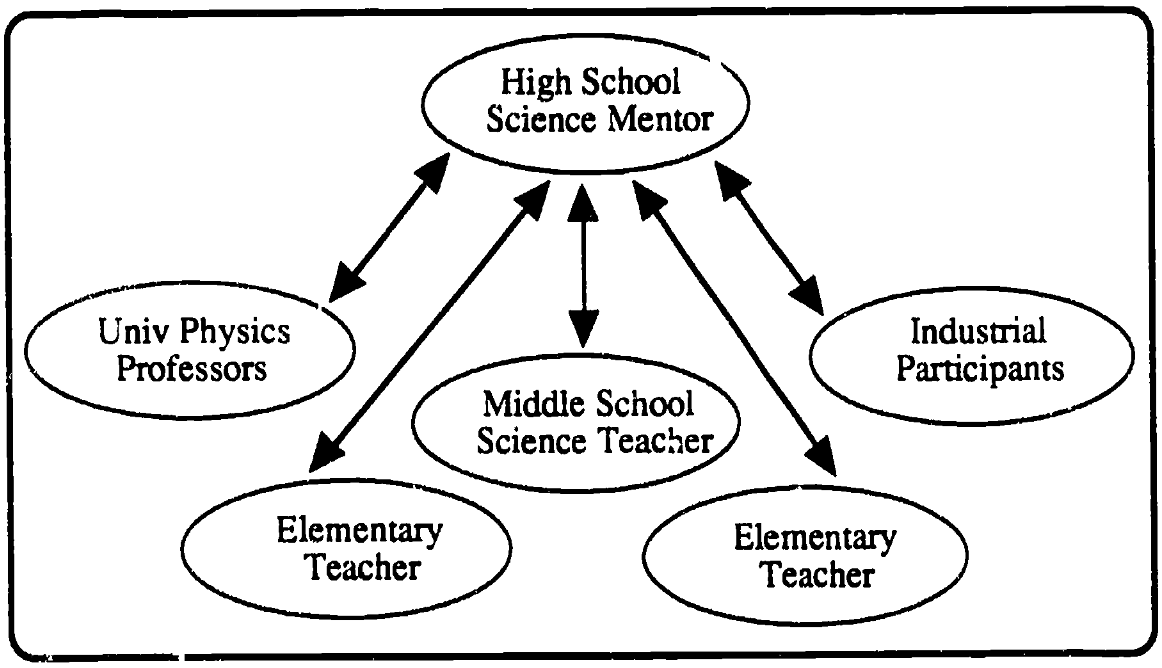

Figure 3: Model for the Peer Mentor Science Network

These interactions are illustrated in Figure 3. The high school science mentors are all master teachers in their respective school systems, who already use science and technology effectively in their classes. This model allows them to share that expertise with those in the middle and elementary schools. Although not shown on the diagram, horizontal interactions (among middle and elementary school teachers, for example) also occur, and sharing and exchange of teaching expertise occurs among all levels. University physics professors and industrial participants on the network also serve as consultants.

Limiting the initial scope of the project has been necessary to identify some of the logistical problems associated with expansion of the implementation. For example, high school science teachers are frequently unfamiliar with the elementary curriculum. Forms were developed to permit elementary and middle school teachers to describe their units. Such forms must be brief, so that they are not unduly burdensome, while at the same time providing the high school science mentors with sufficient detail to determine where they may be of assistance. The intent is to inform mentors of the topics which are covered, and in what depth, so that it is possible for them to work with teachers on a unit-by-unit basis.

Another issue is the question of motivation for science mentors. In the pilot project several of the mentors were provided with personal computers to facilitate their work. This presumably provides some degree of extrinsic motivation. However, over the long term there must be an intrinsic interest in collaboration. Some high school science teachers will find this fulfilling, while others will not. It would be unrealistic to expect all science teachers, or even the majority of them, to participate in this type of interaction. However, many high school science teachers do find interactions with teachers at other levels rewarding. Many of them became science teachers because of interest in explaining and discussing the underpinnings of science, and the mentoring process provides a new and different avenue for doing this. In cases in which motivation and interest already exists, a telecomputing network can reduce some of the barriers to communication, and provide an on-going forum for interaction.

The types of activities conducted include mathematical modeling, creation of simulations, and exchange of materials, models, and graphs via the network. The network makes it possible to transfer information across platforms (i.e., from Apple to IBM). This allows teachers to share a common base of instructional tools in their collaborations. In addition, mathematical and science problems are posed via the network, and solved collaboratively using a variety of tools such as hypermedia applications (HyperCard, LinkWay, and HyperStudio), Theorist, Stella, Logo, spreadsheets and databases.

Previous versions of many of these activities were developed in a recent National Science Foundation (NSF) project, Project S.C.A.M.P.: Science, Computer, and Mathematics Professions, recently conducted at the University of Virginia (Mason, 1989). Other activities were developed by the science teachers themselves, and include development of software simulations and science tools, lesson plans and activities in areas such as magnetism, rocketry, aeronautics, design of stereo speakers, and the physics of sound. The telecomputing network extends these activities to the field in a collaborative effort among high schools, middle schools, universities, and government agencies.

Summary

Science mentors use the Virginia PEN network to provide support for instructional activities, supplemented by personal visits to each classroom and traditional in-service workshops. The network is also used to allow teachers in different school systems to discuss the results observed in their classrooms. This capability allows them to engage in common problem-solving activities and jointly identify ways of adapting and improving them to meet the needs of individual teachers. The network is also being used to allow students from geographically separated classes to post data and discuss results of experiments. Occasional face-to-face meetings are conducted to identify problems and allow teachers to discuss benefits and limitations of the networked science and mathematics activities.

The model described combines traditional in-service workshops with on-going peer support. It extends expertise at the high school and university levels to the middle and elementary classrooms. By the same token, it permits high school teachers to become familiar with activities in elementary and middle schools. This approach provides an opportunity for increased communication and coordination vertically as well as horizontally.

This project is funded in part by the Virginia Council of Higher Education under the Dwight D. Eisenhower Mathematics and Science Education Act.

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Two-way Video and Audio: Removing the Walls of Schools and Teacher Preparation Institutions

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Introduction and Background

As in the rest of the Rocky Mountain states, Wyoming, through its College of Education at the University, is trying to meet the heavy demand for education, inservice opportunities and support by teachers located in remote schools which are spread over a vast geographic area (although teachers in large metropolitan areas can be just as isolated). The population density is approximately 4.7 people per square mile. It requires eight hours to drive across the State and as much as two to three hours of flight time to deliver face-to-face programs by more conventional means (See Figure 1). The College of Education is also dedicated to the provision of earlier and more frequent clinical experiences in its preservice teacher education program. Thus, there is a significant need to be able to draw on the schools around the state to provide these experiences.

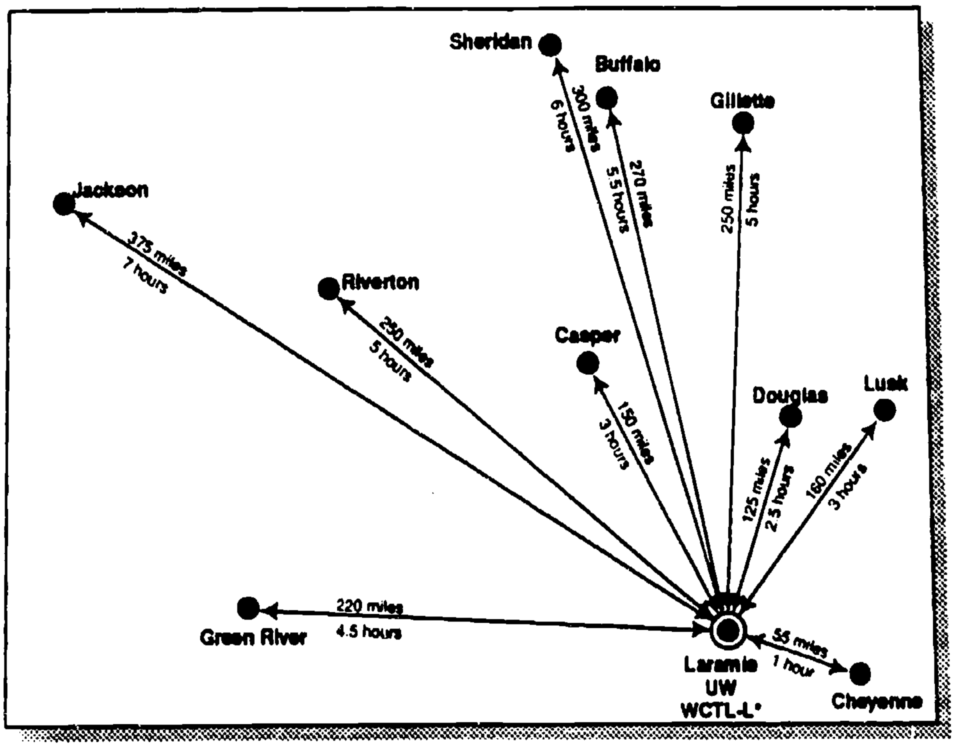
The state has formed a successful school/university/business partnership program. This program relies largely on audio teleconferences, computer networking and face-to-face meetings to exchange information and ideas. The unique capabilities of technology (in particular a compressed video network and computer network) have provided the opportunity to strengthen this resource linking program.

There are no limitations on the kinds, or locations of, other institutions that could benefit from adopting the developmental model for changes in the improvement of teacher education and the renewal of schools which is evolving in Wyoming. The same technologies can be used productively in any distance education situation. Universities and community colleges in this region of the United States—Montana, Idaho, Utah, Colorado, New Mexico, Nevada, and Arizona—all face similar problems in reaching remote schools and teachers. But, these same technologies can also be useful in large metropolitan areas as well.

Currently, Wyoming is operating a highly successful program. The quality of educators in the State is very high, and they are eagerly participating in the development of an innovative information exchange system. The Wyoming School/University/Business Partnership was identified in Washington D.C. as one of two sites for a national, pilot demonstration program for the education of educators and the renewal of schools. The announcement was made at an invitational forum in Washington, D.C. on November 13, 1990, sponsored by EXXON Foundation. Wyoming was selected out of 1,300 possible sites in the nation. The College is already building innovative programs, such as a two-way interactive video network to link public schools with the College and the private sector. The Goodlad School/University/Business Partnership is a model for the sharing of resources and collaborative efforts being used in the State of Wyoming. This

Wyoming Centers for Teaching and Learning Network (WCTL-N)

Figure 1:
The WCTL Network



* WCTL-L (Wyoming Center for Teaching and Learning at Laramie)

model actively involves the University, the public schools, and private business in a collaborative effort to improve the quality of education throughout all levels. This partnership creates a mutually beneficial environment in which to launch cutting edge programs. This environment nurtures programs with nation-wide significance. But, it is the two-way, interactive video part of the network which is opening doors and removing the walls of our educational institutions to provide new opportunities for the improvement of education at all levels

The Wyoming Centers for Teaching and Learning Network (WCTLN) is a newly created office within the College of Education at the University of Wyoming. The WCTLN office is coordinating the design and development of the electronic network. At present, the WCTLN is comprised of ten school districts. These districts are members of the Goodlad School/University/Business Partnership. The Wyoming Center for Teaching and Learning at Laramie (WCTL-L, a laboratory school) serves as the hub of the network.

The WCTLN is integrating a number of technologies including two-way interactive video, audio teleconferencing, audiographics, computers, and mail-out videotape to name a few. The network has potential usefulness to a variety of constituencies in the State in addition to the public schools. The Partnership schools have committed themselves to the development of "electronic classrooms" which contain the necessary materiels to utilize the Network. It is possible for local businesses, government, agricultural workers, health care professionals, community colleges, and University extension courses to negotiate with the districts which are developing the installations to be able to interact on the network. Costs are substantially diminished for each group through the sharing of leased lines and the mutual support of the electronic classrooms in the school districts.

The nation has called for reform in all levels of public education, demanding that our new public school teachers receive more extensive preparation in content areas. It is common knowledge that good pedagogical practice must be learned simultaneously with the content area. In order to prevent new teachers from using ineffective practices for years before they develop real teaching skills, pedagogy must be embedded in their programs, and a coaching or mentoring system must be available to them throughout, and even after, they leave the teacher education program.

In the best of all possible worlds, this would mean a professor in the Education College could serve as a mentor/coach to many students in the program and be available to them frequently while they are engaged in classrooms with learners, to talk about what is going on in the classroom. This scenario is not unlike the way information is exchanged between the referees, the players and the instant replay booth in a professional football game or the diagnostic and intervention strategies used by a surgical team in a modern hospital.

The classroom is a serious clinical/laboratory setting where much coaching, mentoring, exchange and management of visual and audio information must occur in order to produce outstanding teachers. A network which supports real time voice, video and data is required to provide the system for such coaching. This network also provides support for a multitude of other applications. To achieve reform in education, collaborative ventures between all levels of education, business and government are needed to create the networks for the training and retraining of professionals.

Preservice and Inservice Education

The College produces 450 teachers every year. In order to provide earlier and more frequent clinical experiences, the two-way interactive video network is necessary. The WCTL-L cannot possibly provide sufficient clinical experiences for the 1200 full-time students enrolled in the teacher education program at the University. Students in the College are part of cohort groups assigned to a team of three faculty. Each cohort group is linked with a school district and three public school teachers and their classrooms. The videoteleconferencing systems allow each end of the network to operate the camera(s) at the other end, or to operate their own cameras with hand held, remote control keypads which function much like the remote control for a home entertainment center. Students at the University practice using different instructional strategies with learners in the classrooms at the remote site, in collaboration with the public school teachers at that site. Through such interactions, both preservice and inservice learning occurs. As students at the University try new instructional strategies, and new classroom management and decision making techniques, public school professionals have an opportunity to collaboratively apply these new educational developments. In this way, the WCTLN provides clinical experiences which otherwise would not be available. It does not replace being in the classroom physically, but it does help teacher education students move beyond the walls of the University and closer to public school classrooms. Additionally, public school teachers are able to engage in educational renewal opportunities which otherwise would only be available to them during summer school classes at the University, or on weekends or evenings as inservice programs. The WCTLN does provide the opportunity to simultaneously accomplish both preservice and inservice education.

Teacher Support

The WCTLN also provides the opportunity for teachers in different districts and the WCTL-L to team teach to broaden the scope of educational opportunities for their students and to provide equitable access to expertise across the districts. Additionally, the University is able to provide support for its recent graduates or proteges through their induction period. It is possible for a professor at the University, along with a public school teacher, to collaboratively observe and assist proteges. Proteges are able to interact with preservice students at the University through cross maturation level tutoring. While the latter can be seen as immediately beneficial to the University students, it also provides teacher support for proteges through the reinforcement of their own knowledge about the teaching and learning process.

Cooperative Learning

Three levels of cooperative learning occur on the network. Students in the WCTL-L engage in learning activities with students in each of the schools on the network. Additionally, preservice students are engaging in cooperative learning with public school teachers around the state and teachers in the WCTL-L work cooperatively with their counterparts in the networked districts to conduct educational research and apply the results of their findings in their classrooms.

Coaching and Mentoring

The availability of the WCTLN provides us with an entirely new dimension to coaching and mentoring—distance. Until the WCTLN was conceived, the College relied on professionals who were specifically hired to "observe student teachers". These observers were, at best, able to visit student teachers once or twice during the student teaching semester. The Network has made it possible to provide coaching and mentoring on an ongoing basis, not only during student teaching, but also during an induction period.

Faculty Development

A significant factor in the improvement of teacher education is faculty development. New knowledge is emerging at such a rate that it is difficult for faculty to keep up in their own professions. As faculty increasingly immerse themselves in the plethora of literature being generated in education, they also further remove themselves from the day to day functioning of schools. Cohort groups and teaching teams from the College are in contact with schools on the WCTLN for three to four hours per week. We believe this exposure to schools on a consistent basis will help faculty relate research and development in their fields directly to schools. The team approach of three University faculty and three public school teachers linked through the Network has also created the environment to conduct classroom oriented research.

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Technology for Teacher Education in Science and Mathematics

SCIENCE & MATHEMATICS

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The authors of papers in this section have approached the problem of incorporating technology in teacher education in a variety of ways. Some focus mainly on ways to use technology with K-12 students, some focus on ways of engaging teachers with technology for their own learning, and some attempt to combine these two approaches. Given the limited state of our knowledge about how to use technology in science and mathematics instruction for both K-12 students and teacher education, all of these approaches have merit. Indeed, these and many other attempts to find out how best to use technology are needed in the next decade.

Survey of the Papers

Trish Yourst Koontz: *Technology in Middle School Physical Science: Gender Equity Issues*

Koontz addresses one of the most critical issues in the education of teachers about the integration of technology in science teaching; that issue is gender equity. She was fortunate enough to have funding to conduct her inservice program twice, so that she could make adjustments when one of the project's essential goals did not seem to be achieved adequately by the participants. The adjustment was to ask teachers to engage in self-monitoring of their gender-fair behaviors. The use of self-monitoring by teachers is consistent with programs like GESA (Grayson & Martin, 1988) aimed more generally at gender and ethnic equity in the classroom. In spite of its success at changing teacher behaviors, however, this technique does not seem to be commonly used in teacher education programs. Perhaps the success reported by Koontz with middle-school science teachers will encourage more people to develop ways to incorporate this technique into teacher education programs, both preservice and inservice. That the project also seemed to be successful at encouraging teachers to use technology seems almost incidental, even though that was one of the original, main objectives of the project. Helping teachers first recognize their own limitations at involving both boys and girls in science and then increasing the equity of that involvement is probably a more pressing problem than "merely" using technology in mathematics and science instruction. Koontz has helped structure one approach that seems effective for moving toward gender equity. As such, her project is a very important early step at solving a difficult problem.

David M. Podell, Sally Kaminsky, and Vincent J. Cusimano: *Preparing Teachers for a Science Microcomputer Laboratory Approach to Instruction in Secondary Physical Science*

Podell, Kaminsky, and Cusimano begin with a technology-rich program for high school students; much of the paper explains the effects that this program had on students and on the classroom instruction in the schools participating in the field test of the program. The knowledge gained from this trial, however, also suggests concerns that must be dealt with in adapting teacher education programs to prepare teachers to infuse technology in instruction for students. Considerably more study of techniques for preparing teachers to use technology is needed, however.

Patricia Baggett and Andrzej Ehrenfeucht: *Modernizing the Arithmetic Curriculum Using Calculators*

Baggett and Ehrenfeucht have attempted to structure an innovative curriculum for young children that begins with the assumption that calculators will be available for children at all times. This assumption has relatively extensive implications not only for the particular instructional techniques used but also for the specific mathematics that teachers must be ready to deal with. In particular, this approach provides a clear example of the notion that giving students intellectual power (in this case in the form of a calculator) almost certainly means we adults have to rethink our biases about what concepts and skills those students can learn. Much more discussion of our biases is clearly needed if teacher educators are going to agree on a philosophy of teaching arithmetic.

Sunday Ajose: *Redesigning Elementary Mathematics Education Programs for the Technological Age*

Ajose describes in generic terms the kinds of computer activities that might be included in the mathematics education preparation of elementary teachers. The notion of reflection by the teachers on those computer activities seems very important and probably deserves considerably more discussion.

Morris Beers, Mary Jo Orzech, and Anne H. Parsons: *Preparing Mathematics Education Students Using a Computer-Based Classroom*

Beers, Orzech, and Parsons are coordinating the infusion of technology in a teacher education program through the use of one of the IBM teacher education labs that were awarded to several dozen colleges and universities in the late 1980s. Prior to that time, no one to my knowledge had seriously attempted to integrate computers fully into mathematics methods instruction. Consequently, the experiences of this project are quite valuable in setting the stage for understanding the types of outcomes that might be expected from such integration. The successes reported appear to be more in the affective rather than in the cognitive realm, but affect seems to be a critical component of future teachers' use of technology with students. As this and other IBM teacher education labs begin to report the results of their efforts over the next few years, it will be important for us to try to identify the common characteristics of success in all kinds of methods courses. Only then will we begin to be able to develop a theory that will support future improvements in methods instruction.

George W. Bright, Virginia E. Usnick, and Patricia Lamphere: *Computer Inservice for Teachers of Mathematics, Grades 6-10*

Bright, Usnick, and Lamphere have developed an inservice program for mathematics teachers in grades 6-10 that is based on the assumptions that these teachers have not learned mathematics in the presence of technology and that the experiences of the teachers should resemble those that the teachers might provide to students. There may be an additional, unstated assumption, namely that the teachers' experiences need to be at a more sophisticated level than the experiences that these teachers will provide to students. The content of this inservice program deals with geometry/visualization and variables/graphing; this content was deliberately chosen to exploit the power of computers to do things that are normally not possible (or at least not easy) with paper and pencil. Other teacher educators may not agree with the particular choices, but the authors' position begins to open dialogue about the kinds of experiences that ought to be part of preservice and inservice education about computers.

Leah P. McCoy: *Integrating Technology into Secondary Mathematics*

McCoy provides some sample lessons on the use of calculators and computers in teaching mathematics in high school. Although these models need to be tested by real teachers in real classrooms to find out exactly how well they work, they are clearly consistent with suggestions that others have made about this topic. The lessons were initially developed in a teacher education program, and they seem like a good point to begin discussion of the integration of technology in mathematics instruction.

George W. Bright: Statewide Inservice on the Use of Computers in Teaching Mathematics in Grades K-10

Bright describes a plan used in Texas to provide inservice on computers in mathematics throughout the state. The main strength of the plan is that it attempts to maintain quality control over the experiences that teachers participate in, while providing inservice for large numbers of teachers. In addition, materials were provided for parallel inservice programs for school administrators and school board members. It is critical that teacher educators begin to determine which groups *besides teachers* need to become involved in the process of providing teacher education programs on technology. Many public groups have investment in education (e.g., legislators, parents) and to ignore them will seriously jeopardize the potential success of teacher education programs, especially those programs that deal with relatively expensive technology. Perhaps this article will help open discussion on this important matter. Too, while local teacher education efforts are important, large-scale programs need to be implemented if there is going to be a significant impact on K-12 instruction. The "Texas model" is one way to go about large scale efforts.

As You Read On

There are three main concerns that must be addressed in the infusion of technology in science and mathematics instruction. How do we use technology with students? How do we prepare current teachers to use technology? How do we prepare future teachers to use technology? Although these are related concerns, there are important, different problems across the areas.

An analogy comes to mind, namely the development of cognitively guided instruction (CGI) by Carpenter, Fennema and their colleagues (e.g., Peterson, Fennema, Carpenter, & Loef, 1989). The first success in that project was the description of how young children think about addition and subtraction problems. Then a question was raised about whether sharing this knowledge with inservice teachers would improve mathematics instruction and student performance. It did. Only then did attention turn to whether preservice teachers could also learn to internalize the information in order to improve the effectiveness of their instruction during the first few years of their careers. We do not yet know whether this is possible. Some people believe that it will be easier to "teach" preservice teachers, since they have fewer biases about how children learn. Other people believe that it will be more difficult because preservice teachers have so little experience working with children during the learning process. Whether one of these scenarios or some other one is correct is yet to be determined. And whether a similar plan of research and development would work in dealing with the infusion of technology in instruction is a question that we are clearly not ready to answer.

As you read the following papers, try to keep the three areas of concern separate in your own mind: K-12 instruction, inservice education, and preservice education. After you have read the papers, reflecting on the relationships among the three areas is a way to bring some coherence to your new understanding of how to begin to incorporate technology into teacher education. Finally, make explicit the questions that you still have about this very difficult process. Discussion of unanswered questions among colleagues will help move us all toward a deeper understanding of the next steps we should take.

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Technology in Middle School Physical Science: Gender Equity Issues

Trish Yourst Koontz
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Many documents have forced Americans to reflect on our lack of achievement in math ematics and science. McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers, and Cooney (1987) compare the content curricula, quality of teaching, and students' achievement and attitudes in the United States to that of 17 other countries, more often than not ranking the United States below the average. The American Association for the Advancement of Science (1989) gives recommendations for a common core of ideas and skills having the greatest scientific and educational significance for all citizens. The National Research Council (1989) also urges educators and other leaders to concentrate on educational reforms focusing on all Americans, including African-Americans, Hispanics, American Indians, and women.

To work, educational reform must cut across all levels of education. However, one level frequently singled out as the time in which students lose their interest in science is the middle school years. To teach middle school science appropriately to all children, two major concerns should be addressed. First, many middle school teachers feel they have inadequate content preparation, having had only 6 to 9 hours of science credit required for elementary certification. Usually biological sciences are studied over physical sciences. Weiss (1987) reported that only 22% of elementary teachers felt qualified to teach science as compared to 66% feeling qualified to teach reading. Coupled with the lack of awareness of appropriate teaching strategies, such as questioning skills, use of manipulative materials and computers, classroom management during hands-on experiences, etc., it is understandable why a substantial number of teachers do not enjoy teaching science (Helgeson, Blosser, & Howe, 1977).

The second concern—gender bias—is so subtle we barely recognize it. The major obstacle to overcoming gender bias is that its deeply ingrained nature makes it practically invisible. Most teachers will proclaim that they feel equal treatment of the sexes during class time is essential. These same teachers honestly believe that they practice gender-fair behaviors in their own classrooms. In fact, it was found in the first cycle of this project that making teachers aware of gender-fair practices was not enough to produce any significant teacher behavior change toward gender-fair practices in the classroom. Awareness of equity issues is the first step to change, however. With most funding agencies willing to support projects for only a limited time, what inservice strategies are sufficient to propel teachers beyond the awareness stage? This project found at least one strategy that has much potential, namely, self-reflection of teaching using video tapes.

Project Description

Goals

There were four primary purposes of this research and staff development project:

1. increase knowledge of physics content to lessen the feeling of inadequate preparation in physical science areas by elementary school teachers
2. increase skills, knowledge and attitudes toward alternative teaching techniques utilizing concrete materials appropriate in the teaching of physical science in the middle school years
3. increase positive attitudes and awareness of the needs of females in the study of science by including role models, hands-on experiences with equal chance of participation, information on career opportunities, and utilizing other strategies that decrease the illusion of science as a masculine Caucasian domain
4. increase knowledge, skills, attitudes, and values of integrating computers, into the study of science during the middle school years, through an emphasis on use of simulations, graphing software, data bases, and interfacing probes

General Plan

By utilizing a model of effective change in schools, this project sought to develop a workable model for implementation of manipulatives, technology, and equity strategies into the middle school science classroom by the following:

1. conducting regular meetings throughout the project to promote sharing of ideas and cooperative decision making
2. providing manipulatives, software, and interfacing light and temperature probes for participants to keep and/or use in their classroom (e.g., rocketry kits, simple electronic materials, Legos for the study of simple machines and forces and spatial visualization activities)
3. providing classroom assistance by project staff for infusing manipulatives and technology into science instruction
4. providing female and African-American scientist role models from local business and industry as participants in the middle school classroom
5. providing direction and materials to encourage participants to create their own science mini-units that utilize technology, manipulatives, and role models

Inservice Model

The model was composed of four phases in each of two cycles. Forty middle school science teachers (20 in each cycle) were selected to participate. Phase I consisted of selection of 20 teachers followed by surveying of their attitudes, existing classroom practices, and physical science knowledge through questionnaires, interviews, and video taping of instruction. Participants were selected by a panel that judged applicants on the basis of written essays of their philosophy of teaching science, the need for improvement of computer and physical science background, willingness to disseminate what they learned to other teachers in their buildings, and school districts commitments to have at least two computers in participants' classrooms on a regular basis. In addition a database was created of females and African-Americans working in science careers in local business and industry who would help the teachers whenever possible during the last three phases of the project.

Phase II upgraded the participants' instructional computing skills through a 3-semester-hour course emphasizing the use of computers and manipulatives in science instruction as well as strategies to promote gender/minority-fair instructional practices. The following topics were studied, using techniques like those which might be used in teaching middle school students (e.g., cooperative learning groups, hands-on experiments, skits):

1. introduction to computers: computer components and how they work, binary code, constructing a bit counter, history of computing devices
2. critiquing science software (e.g., *Rocky's Boots, Gears, Machines and Forces, Discovery Laboratory, Forecast*, graphing packages)
3. light, heat, and earthquakes: use of *Science Toolkit* probes for experimentation (e.g., change in temperature during oxidation of a classroom compost pile, reflection and intensity of light from different phases of the moon)
4. spatial visualization: weekly homework on spatial activities, *Lego-Logo* activities (e.g., conveyor belt, egg beater, lawn mower)
5. databases: card sort activity as a conceptual model, group and individual work with software
6. telecommunications: use of a university bulletin board, middle school students communicating with other students from nearby school districts
7. motion and rocketry: investigation of Newton's three laws with use of *Science Toolkit* launching of model rockets, use of software on rocketry (e.g., *Introduction to Rocketry* and *Physics of Rocketry* by Estes Industries)
8. equity issues and strategies: awareness about research on gender equity issues in mathematics, science, and computer instruction; biweekly equity assignments to use with middle school students; open discussion of common equity situations that occur in children's lives

Before studying databases each participant was given a potted flower and the growing conditions of a plant. They were asked under what conditions could they produce short, blue flowers with broad leaves. After a long period of time and much cooperation it became obvious that there must be an easier way to solve the problem. It was then that a database was introduced. This 'Moon Seeds' activity showed participants how to create and use a database for solving problems.

One main objective of the equity assignments was to make the teachers aware of their students' feelings about equity issues. A variety of resources were used (Erickson, 1986; Fraser, 1982; Lewis & Davies, 1988; McClintock Collective, 1988; Sanders & Stone, 1986; Skolnick, Langbort, & Day, 1982; Stenmark, Thompson, & Cossey, 1986).

Phase III consisted of two, 2-semester-hour physics courses to upgrade participants' science knowledge and to give them hands-on laboratory experiences similar to those they could incorporate into their own classrooms. This phase lasted seven weeks in the summer.

The first course was a physics course designed for middle school teachers. Through demonstrations and practical applications the following physics topics were investigated: motion, simple machines, light, heat, sound, electricity, wave theory, and application of newer topics such as super conductivity.

The second physics course was a laboratory course in electronics. The course was designed to fulfill an expressed need of the participants. During the computer course the participants on numerous occasions said, "This is great but my students couldn't do this!" With further questioning, the participants confessed they felt very inadequate in the understanding of electronics, how a computer works (hardware), and how the interface box/probes worked. They expressed the fear of using the probes because a student might ask "Why or how does this work?" With much trepidation the participants brainstormed that a hands-on electronics course might be very helpful. Therefore, a new course was designed to center around electronics and to have each participant build an interface box. At the end of the course many experiments were performed with these interface boxes (e.g., how does a smoke detector work?).

In Phase IV, participants created their own mini science units utilizing what they had learned about computers, gender equity strategies, and physical science. Parts of each unit were video taped and then analyzed for appropriate teaching practices, correct science content, and use of equity strategies. A more complete description of the four phases including more information on lessons (e.g., 'moon seeds database') and on the schematics and programs for the interface boxes is available from the author for a minimum charge to cover copying and postage.

Table 1
Comparative Data: Cycle 1 Verses Cycle 2

Variable	Cycle 1	Cycle 2
Mean Score Physics Test: Pre	62.3	60.5
Mean Score Physics Test: Post	89.4	91.1
Previous physics course: Female (%)	30.7	28.6
Previous physics course: Male (%)	80.0	100
Previous physics course: Total (%)	44.4	44.4
Perceived self as equitable: Pre (%)	88.9	94.4
Displayed Equitable Teacher Behaviors: Pre (%)	38.9	44.4
Displayed Equitable Teacher Behaviors: Post (%)	33.3	83.3
Instructional Techniques: Post		
Primarily Lecture (%)	38.9	0.0
Primarily Demonstration (%)	27.7	5.5
Primarily Hands-on (%)	33.4	94.4

Evaluation of the Project

Table 1 summarizes much of the information gathered in both cycles of the project through interviews, tests, videotaping, and questionnaires. Even though 20 teachers were selected for each cycle, in each case 2 teachers were excluded form the data due to illness or missing data. The only change made from Cycle 1 to Cycle 2 was in Phase II when teachers were participating in a course on computers and equity in science. This change will be described in the discussion below.

The first of the four objectives of the project was to up-grade the teachers' knowledge of physics. Prior to the project 44% of the teachers in each cycle stated that they had successfully completed a high school or college physics course; fewer than that felt comfortable teaching about physics concepts or applications. The grades on the physics final indicated the participants took the course seriously. In both cycles teachers performed quite well; the average grade on the final was an A-/B+. At the end of the project the participants reported having a better understanding of physics concepts, held a more positive attitude towards physics concepts, and were slightly more confident about teaching a physics unit than at the beginning of the project. The analysis of the post-project video tapes showed that only one teacher in Cycle 1 and two teachers in Cycle 2 had difficulty explaining physics concepts during their mini unit when children asked for an alternate explanation.

The second goal was to increase skills, knowledge, and attitudes toward alternative teaching techniques utilizing concrete materials appropriate in the teaching of physical science in the middle school years. At the start of the project, teachers in both cycles noted that they used hands-on materials approximately once ever six weeks. At the end of Cycle 1 this figure had increased to almost once per week. One of the major increases came from the use of spatial visualization activities on a regular basis. However, analysis of the videotaped lessons at the end of Cycle 1 revealed that 39% of the teachers used straight lecture, 27% used teacher demonstrations, and only 33% arranged hands-on activities for their mini unit. Use of spatial activities and puzzles apparently increased but experimentation had not reached the level hoped for at the start of this project.

Cycle 2 teachers had an additional requirement for the assignments that were to be completed with their middle school classes. They were given specific teacher behaviors to assess. Each assignment was audio or videotaped and self-critiqued using an adapted version of the Classroom Observation Checklist. Teachers were not required to share every critique with the project staff; however, I was delighted to hear their anecdotal comments about their own teaching. One teacher said she hadn't realized how boring it was to just watch the teacher do all the fun stuff. Another said she were embarrassed when right on the tape a fifth grader asked, "Why can't we ever touch the computer?" as the teacher was demonstrating a property of light with the light probes. This self-critique process seemed to make a significant difference in the participants' format of lessons. When tapes of the mini units of Cycle 2 teachers were analyzed, it was observed that not one teacher used straight lecture. Surprisingly, 94% arranged for hands-on experiments for the children, most often using cooperative learning and computer experiences.

The third goal of the project was the use of gender-fair practices in science classrooms. Participants were not informed that this was a research project; they were only informed of the instructional grant funded by the Eisenhower Program. At the beginning of the project all 20 middle school teachers in each cycle were interviewed to gather baseline demographic data and information on their belief system about equity issues in the schools. Questions such as the following were asked: How many mathematics, physics and computer courses have you had? Do you use the computer as a tool for teaching? Name some situations in your classroom (in your school building, in the work force in general) that may allow obvious gender inequities? What strategies do you use in your classroom to overcome inequities if there are any?

Video tapes from the beginning and end of the project were also analyzed for the frequency of gender-fair practices, including the following:

1. questioning of both males and females equally no matter whether it was a high or low level question (e.g., synthesis verses rote)
2. ratio of asking girls to boys to use the computer
3. ratio of girls to boys being asked to set up and perform experiments
4. use of cooperative learning with equitably assigned roles (random or rotating assignments)
5. use of role models

Table 1 lists data on both cycles for variables such as (a) the participant's initial self perception about equity issues and (b) the degree to which each participant practiced gender-fair behaviors during the piloting of the mini unit they designed.

In both cycles initially all but one participant rated themselves as either very aware or somewhat aware of gender-fair practices in the classroom. However, outside raters agreed that only seven of the Cycle 1 participants would be classified as somewhat utilizing equity-fair practices, and nine of the Cycle 2 participants as being able to recognize overt inequities. There was no significant difference in awareness levels (based on both self-perceptions or raters' perceptions) between gender groups of participants.

Of all four goals of the project, the gender equity goal appears to be the one least attained in Cycle 1. Teachers were definitely aware of equity practices but had not carried it into the classroom. Analysis of video tapes of Cycle 1 shows teachers selecting a boy and a girl to demonstrate a concept, but in each case the boy was assigned the more technical role. There was a significant increase ($p < .001$) from Cycle 1 to Cycle 2 in the number of teachers encouraging gender-fair practices in their classrooms. Participants in Cycle 2 did not know about the results of Cycle 1, yet in Cycle 2 role models and cooperative learning were used more frequently than in Cycle 1. Again, the only major change between the two cycles was the mandatory self-reflection activities after each student-based lesson. It appears that practicing a strategy, behavior, or content area with a self-critiquing process built in is an important step to internalizing its importance.

The fourth goal was to increase the teachers' use of technology in the science classroom. At the beginning of the project 18 of the Cycle 1 participants did not use computers in the teaching of science as compared to 16 of the Cycle 2 participants. Only drill and practice programs were used by those that did use computers. By the end of the project all teachers had used the computer at least 4 times in their classes even though a few teachers had difficulty securing a computer. At the end of the project all but one teacher felt comfortable with interfacing the computer with probes to perform science experiments. The participant were all very favorable to the initial survey computer course and the electronics course, but lack of computers in the school was now most often sighted as a reason technology would not be used on a regular basis in their science classrooms. Encouraging teachers to continue regular use of computers in the science classroom was the second most difficult goal to accomplish, next to the gender-fair practices goal.

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Preparing Teachers for a Science Microcomputer Laboratory Approach to Instruction in Secondary Physical Science

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This paper discusses the implications of a science microcomputer laboratory approach for teacher education. In the implementation of such a program in ninth-grade physical science classes, students showed greater interaction, self-monitoring, and student-initiated questions. To make such an approach effective, teachers must understand ways in which technologies affect learning, learn to act as facilitators of knowledge, carefully plan and organize activities, keep students on-task, and pair or group students for optimal learning. Science educators must remain aware that the technologies themselves do not guarantee student learning. Informed use of technologies by well prepared teachers is necessary if technologies are to contribute to the improvement of science instruction.

While computers have been an integral part of scientific research since their inception in the late 1940s, only recently have they begun to have a role in secondary science classrooms. A recent assessment (Martinez & Mead, 1988) indicated that about 85% of eleventh-grade students have never used a computer in their science classrooms. Administrators are gradually realizing the importance of microcomputer-based instruction to students' achievement and preparation for the workplace and are consequently budgeting for microcomputer laboratories for their schools (Ellison, 1989). At the same time, science educators are increasingly using microcomputers (e.g., Nachmias & Linn, 1987) and their application software, including graphing (Brasell, 1987), spreadsheets (Graham, 1987) and simulations (Rivers & Vockell, 1987). As this technology becomes more important in the science classroom, there will be a greater need not only to prepare teachers to use the technology, but also to make them knowledgeable about how the technology changes the teaching/learning environment.

While researchers have investigated the influence of microcomputers on various student outcomes (e.g., Hounshell & Hill, 1989), little attention has been paid to the needs of teachers who will be expected to incorporate new technologies in science instruction. Gittinger (1989) highlights the need to enhance science educators' perceptions of the computer as (a) a tool for instruction (e.g., using word processing, statistics or graphics software), (b) a medium of instruction (e.g., graphically representing data), and (c) a context for instruction (e.g., using simulation programs). Unfortunately, teacher education programs seldom prepare teachers to use the computer as a medium or context, focusing instead on its function as a tool. Gittinger asks, "how do we expose students of science to the various impacts of computer technology on the process of doing science?" (p. 4). We would further ask how do we prepare teachers of science to convey to students the impact of computers on the process of doing science.

Program Description

The Partnership for Technology in the Physical Sciences Program (Partnership Program), funded by the National Science Foundation in collaboration with IBM and the New York City Board of Education, is currently operating in five New York City public high schools. The program offers an alternative to traditional science instruction. In the program, instruction focuses on the development of science process skills through demonstrations, hands-on activities, and problem-based discussions using the microcomputer as a tool, medium, and context for instruction. In addition to learning science process skills and content, students learn microcomputer utilities, such as graphing, word processing, use of spreadsheets and data bases, and data analysis. The present paper focuses on (a) the impact of the program on teacher and student outcomes, and (b) the preparation of science educators for teaching in a microcomputer laboratory environment.

Curriculum and Technology

The Partnership Program relies on problem-based instructional modules using various technologies to enhance science knowledge and problem solving. Each module focuses on a problem in physical science and emphasizes process skills, such as data collection, experimental design, and theory formation. Students working with the modules engage in forming hypotheses, planning experiments, controlling variables, collecting data, and drawing conclusions.

Working in pairs at microcomputer workstations, students collect data in real time using various probes connected to a microcomputer, including measures of temperature and light. The students use spreadsheets and graphing programs to manipulate and analyze data, and employ word processing to document their results. The instructional modules include introduction to energy; mechanical energy and machines; sound energy; light, energy and electromagnetic waves; heat energy; electrical energy; science, technology, and society; matter; chemical shorthand; and energy sources.

Participants and Setting

The five schools differed with regard to students' socio-economic background, academic performance, and ethnicity, as well as existing computer availability. In each school, a networked microcomputer laboratory was installed and science probes and other technologies were made available.

Participating science teachers varied in teaching experience and computer background. They were given comprehensive training in the use of the technologies in science instruction and were introduced to the software developed specifically for the program. Training included an intensive three-day seminar and hands-on demonstration of hardware and software at IBM facilities, and considerable on-going school site support by program personnel.

Ninth-grade students in each school were randomly assigned to either experimental classes (those using the microcomputer laboratories) or control classes. In the latter, physical science instruction was provided in a traditional format. Students in the experimental classes were given instruction in the use of the microcomputers and probes, and were taught how to use the graphing, spreadsheet, and word processing programs.

Program Impact

Impact on Student Outcomes

At present, the program has been examined in two pilot schools and its effects on student outcomes are highly favorable. (For a comprehensive review of program impact, see Kaminsky, Podell & Cusimano, 1991). As compared to students in the control group, a greater proportion of those participating in the program passed the New York State Regents Competency Test in Science, a 70-item examination covering physical, earth, and life sciences. When scores of chronic truants were omitted from the analyses, students in the microcomputer group had a significantly higher mean than their counterparts in the control classes. In addition, participants in the program were more likely to enroll in higher-level science courses in the following year. Further, they demonstrated more positive attitudes toward computers and had substantially better attendance. The latter finding was particularly important given the significant truancy problem currently existing in New York City and other urban high schools.

Impact on Instruction

Perhaps the most interesting impact of the program emerged in interviews with participating teachers, who reported dramatic changes in many aspects of classroom instruction. First, they observed that students demonstrated a heightened level of interaction. Students worked cooperatively, as often occurs in laboratory settings; however, their interaction was perceived as being more focused on genuine problem solving as opposed to simply carrying out the predetermined steps of a laboratory experiment. As students encountered dilemmas in the implementation of their investigations, they reasoned together and shared responsibilities for developing and testing possible solutions.

Second, the teachers believed that the nature of the tasks (in particular, collecting, graphing and analyzing data) required students to monitor their own performance. This led to a greater number of student-initiated questions. Whereas traditional instruction tends to rely heavily on teacher-initiated questions (Dillon, 1985), these classrooms encouraged independent student inquiry.

Third, the teachers believed that this environment made students more responsible for their own learning and encouraged autonomy. However, problems with basic skills such as reading were found to interfere with success in the assigned tasks. This conclusion underscores the need to provide students working in microcomputer environments with support in requisite skills such as reading comprehension, writing, and mathematics.

Fourth, the teachers agreed that an important outcome of the program was student acquisition of computer literacy skills, in addition to science concepts and process skills, which would be beneficial for students' future coursework in science and in other disciplines.

The program also had an impact on the teachers themselves. They reported that they performed differently in the microcomputer laboratory than in traditional science laboratories: they were required to change their approach to address the logistical and curricular problems inherent in a computer environment. Teachers found that they had to become more aware of each student's progress, address students' learning problems as they occurred, become more facilitative rather than directive in guiding students' learning, and work collegially with other teachers to compare experiences and share solutions. They noted their increased motivation regarding teaching, with some more experienced teachers reporting a "renewal" of their enthusiasm for science instruction.

Because students differed in their ability to carry out the experiments, teachers found themselves addressing students' varying needs. Often, small groups emerged as students reached various levels of completion of the task: while some were still collecting data, others were graphing their data, and still others had moved on to a reading assignment related to the experiment.

Implications for Teacher Education

In order for science teachers to work effectively in a science microcomputer laboratory, two levels of preparation are necessary. First, teachers must become knowledgeable about the technology itself; that is, they should be proficient in the use of stand-alone microcomputers, networked laboratories, science probes, videodiscs and various software packages. However, computer literacy alone is not sufficient for teachers to create truly effective microcomputer learning environments. They must become enlightened regarding the many ways in which microcomputers affect learning and instruction.

Specifically, teachers must be cognizant of their role as facilitators, rather than imparters of knowledge. Because students in microcomputer laboratories are granted more independence in their learning, teachers must monitor student progress more closely. They must be prepared to step in when students are heading in a non-productive direction and to stand back and allow students to pursue erroneous strategies when the process may contribute to learning.

Preparation of science educators should emphasize the complexities of microcomputer-based instruction, which are significantly reduced when activities are well-planned. Structure is essential for instruction to be successful. Students will grasp the meaning of activities when goals are clearly delineated. Further, well defined goals, clearly written instructions, and close teacher monitoring will keep students on-task.

Teachers must also understand effective methods of pairing and grouping students since cooperative learning is particularly important in a microcomputer environment (Mevarech, Stern, & Levita, 1987). Strategies for pairing students on the basis of achievement, complementary skills and personality characteristics will optimize learning.

Conclusion

In the wave of enthusiasm that greets the availability of new technologies, science educators must remain aware that the technologies themselves do not guarantee student learning. Technologies should be neither the focus nor the exclusive provider of instruction. The teacher remains pivotal to successful learning. Therefore, informed use of technologies by well prepared teachers is necessary if technologies are to contribute to the improvement of science instruction.

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Footnote

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Modernizing the Arithmetic Curriculum using Calculators

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The *Curriculum Standards* (National Council of Teachers of Mathematics, 1989) claims that calculators should be made available to all students as appropriate. But a curriculum has not been developed which uses calculators centrally from the earliest grades (J. Payne, personal communication, 1990). We have argued that one is needed (Baggett & Ehrenfeucht, in press), and here we give its principles and an overview of what is involved in preparing teachers to teach it.

Principles

Consistency

Arithmetic is currently taught inconsistently. Children are first taught the positive integers and told larger numbers cannot be subtracted from smaller ones and an integer cannot be subtracted from itself. Later in multidigit subtraction, they learn that a larger number can be subtracted from a smaller one within a column, although a larger multidigit number cannot be subtracted from a smaller one. When negative integers are introduced, the rules are changed again; a larger number can be subtracted from a smaller one to yield a negative number.

In division, children are first taught that 7 is an odd number and not divisible by 2. Later they are told 7 divided by 2 is 3 remainder 1. Later 7 divided by 2 is 3 1/2. Finally, 3 1/2 is the same as 3.5. Research shows that children believe mathematics consists of following arbitrary conventions which are randomly changed and established by authorities (Davidson, 1987). No wonder! If children are forced to accept something that is false, they can hardly be expected to learn to reason.

Our approach is that of modern mathematics; in arithmetic we have *real numbers*, and numbers with other names (e.g. positive integers, fractions) are not *different* numbers but are subsets of the real numbers. This does not mean that all real numbers should be introduced simultaneously, but rather that one avoids making statements inconsistent with the framework of real numbers. We start with positive integers, introducing zero when one subtracts two equal numbers. Then we introduce unit fractions when one divides 1 by some positive integer (e.g., in sharing a pizza); irrational numbers in geometry (e.g., square root of 2 as the length of the diagonal of a square with unit sides), and negative numbers as the result of subtracting a greater from a lesser number. In this view all numbers are equal. You can perform all operations on all numbers, except you can't divide by zero.

Linguistic Element

In our approach the goal is to teach students to solve real-life problems. Our curriculum has a large linguistic component; it is built around word problems. We want children to learn to use arithmetic to solve problems that occur naturally in their world.

Children will learn to read formulas with operations and know what they mean. They will be introduced early to spoken decimal notation for integers and informal notation for small fractions. Decimal notation for fractions, especially in counting money, will be introduced early.

Calculator Use

Using a calculator, one is exposed to large numbers, numbers with places to the right of the decimal, decimal approximations to square roots, etc. Young children will see in the display certain kinds of numbers before they need to understand them. Teachers should not stress use of these numbers before there is a need; but when children ask questions, the teacher should answer correctly and consistently. Consistency is key. We will *not* change the rules about how arithmetic operates.

Training Teachers

Several aspects of our approach are non-traditional.

1. The approach is different because we are teaching *real numbers*.
2. From the start we use all four operations.
3. We do not teach everything at the same time, but the selection is non-traditional (e.g., children will probably use -1 earlier than 20).
4. With calculators, the difficulty of different operations is about the same, so adding 2 whole numbers is not really easier than taking the reciprocal of a large number with a decimal point. But understanding a number is different than computing with it, and some things are more difficult to understand than others.
5. By making computation easy, teaching is challenging on an intellectual level. We think that, if properly handled, this approach is not above the ability of children in grades K-4.

We are providing a set of problems, each with four parts: content, mathematics (formulas), calculator use (programs), and interpreting results. The actual way to teach the problems is up to the teacher. We also provide a survey of basic mathematical facts that should be taught, a description of our approach, a glossary of mathematical terms and linguistic elements, an explanation of concrete versus abstract numbers, and an appendix of algorithms that can be executed on a calculator. We want teachers to know what they can actually do with that tool. We plan to try out our curriculum in grades K-2 in Fall 1991 in Jackson, Michigan.

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Redesigning Elementary Mathematics Education Programs For The Technological Age

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In less than two decades, computer technology has radically transformed the world of mathematics, opening up new channels of research and exerting a strong influence, not only on what areas of mathematics are deemed important but also on how mathematics is done (National Research Council, 1990). At the pre-college level, this technology has spawned a new vision of mathematics education where the computer becomes standard classroom equipment; students freely use computers and calculators to learn mathematics, and the focus of instruction is no longer on mere computation and regurgitation of facts, but rather on reasoning, communication and problem solving (National Council of Teachers of Mathematics, 1989). Clearly, these new emphases and expectations present a challenge to all mathematics educators.

For many classroom teachers, the challenge is to find ways of coping with a technology for which they are, by training, unprepared. For teacher educators, it is to design programs that will enable practicing and preservice teachers to respond positively to a technology that is rapidly changing and growing by leaps and bounds. What follows is the outline of a program designed to prepare prospective elementary school teachers to exploit the potential of computer technology for teaching and learning mathematics.

Basic Assumptions and Objectives

The following assumptions are made for our discussion:

1. A microcomputer lab, equipped with a good selection of mathematics education software, is available for the implementation of this plan.
2. If prospective teachers are taught in a way similar to how they are expected to teach, most of them will live up to the expectation.

The main objectives, following Ronen (1990), are the following:

1. To provide preservice teachers with the practical knowledge they will need in order to use existing computers and relevant educational software in a pedagogically sound manner
2. To help develop "the general understanding," (p. 26) that will make future teachers want to consider for adoption and use, further developments in the technology

A Plan

The basic plan is to integrate computers and calculators into the teaching of all mathematics content and methods courses in elementary teacher education programs. The mathematical component of elementary teacher education programs usually come in one of two forms. The first consists of a course or two, in which the system of real numbers, topics in elementary number theory and concepts of Euclidian Geometry are carefully treated. Because these courses are usually designed specifically for elementary teachers, their content is closely related to elementary school mathematics. These content courses are followed by a methods course, in which prospective teachers learn how to teach school children mathematical concepts and skills. The second form consists of a single methods course, in which concepts of elementary school mathematics and methods of teaching them are combined.

In the first case, instructors should demonstrate within the content courses, the use of technology in lessons aimed at concept development, enrichment, drill and practice, and the attainment of higher order cognitive skills. Being thus put into where they use technology to learn mathematics, the future teachers will begin to develop informed opinions about this mode of teaching and learning.

To encourage deeper reflection on these experiences, students should be asked to write about each lesson in which computers or calculators are used. In their writings, students should freely share their honest opinions about issued such as:

1. The wisdom of using computers or calculators in a particular lesson (e.g., Was the use of these tools appropriate for the occasion? Was there a better way to attain the objectives of the lesson?)
2. Whether or not (and if so, how) the medium used facilitated their understanding of concepts and the mastery of skills
3. Whether or not (and in what ways) the increasing use of computers to learn has an impact on their learning styles (e.g., Are they becoming more active learners, willing to explore concepts in greater depth?)

These reflections will help future teachers develop the ability to, among other things, make sound judgements about when and when not to use computers in teaching mathematics. Those responsible for teaching these courses could also use the feedback from students to refine and improve the courses.

These content courses should also be used to demonstrate how computers can be effectively used for evaluation and record keeping. Properly modeled, these applications would enable the prospective teachers to see how computers could save them time while, at the same time, provide for greater individualization of instruction.

In their subsequent methods course, the students should be required to prepare lesson plans in which computers or calculators are to be used to accomplish different objectives. They should be required to discuss instructional principles behind their choice of software in each of the lessons, and actually microteach at least one lesson in which the computer is used to teach a specific concept or skill. Other useful activities might include:

1. Doing critical reviews of existing software
2. Designing original applications of selected software
3. Preparing a proposal about a piece of software that they would like to see developed for teaching a topic in elementary school mathematics

It is not enough for teachers to simply make do with whatever the software industry produces for the schools. Teachers have to be empowered to decide what they need and let the software developers worry about meeting the needs.

In the case where the teacher's mathematics education is provided in a single methods course, it would be very difficult to do all the activities described above. This methods course is often so concentrated that any new content added is done at the expense of other important topics. However, each instructor should do as many of the suggested activities as time permits.

The suggested integration of computer technology into the mathematics education of elementary school teachers should in no way diminish the need for teachers to be proficient in the use of concrete manipulatives for teaching the subject. Children construct their knowledge of mathematics by interacting with appropriate concrete materials; and teachers need to be highly skilled in the use of manipulatives if they are to succeed in facilitating their students' learning. Computers can, however, help children bridge the gap between the concrete and the abstract levels of learning in a much more dynamic, interesting and beneficial ways than textbooks currently do. Consequently, teachers should also be prepared to use the computer, which seems destined, in the very near future, to become our principal educational tool.

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Preparing Mathematics Education Students Using a Computer-Based Classroom

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The first phase of integrating information technology into the teacher training curriculum at Brockport began in the Fall semester of 1990 when the Elementary Mathematics Methods course was taught in the new computer laboratory facility. The hardware and software which make up most of the laboratory were received through a grant from the IBM Corporation. The equipment arrived on the Brockport campus during the Spring semester of 1990 and the laboratory was set up in the late summer.

The heart of the Teacher Education Computer Laboratory is based on a Local Area Network (LAN) of 15 IBM PS/2 Model 25s running on a Base Band network with an IBM PS/2 Model 80 as the file server. All IBM educational software is available to teacher education students on the file server. There are also two IBM Proprinter III dot matrix printers attached to the network. In the near future, the network will be tied to the outside world by means of a modem.

In addition to the IBM Baseband network, students have access to an InfoWindow system which is an interactive multimedia station linked to an IBM PS/2 Model 50Z and a Pioneer Model V6000A Laser Disk player. Students also have available, in a different building, a full desktop publishing station based on an IBM PS/2 Model 70 computer, an IBM 8514A high resolution monitor, and an IBM Personal Page Printer Postscript laser printer.

The focus of the grant is to implement computer and information technology into all aspects of the teacher training programs at Brockport. This will assure that new teachers entering the field will have the background and experience necessary to use the equipment they will find in the schools. It will also benefit the present school teachers in that they will be getting new colleagues who have been trained in the use of technology and can help them acquire essential skills.

The first phase of the implementation of information technology into the teacher training curriculum focused on the Elementary Mathematics Methods course taught by the principal investigator. Since the grant provided considerable software in the elementary mathematics area, this was a good place to begin.

There are four sections of the Elementary Mathematics Methods course each of which meets for a total of twelve 90-minute sessions. Each session is focused on a topic and the lecture presentation, manipulative activities, and computer activities center around that topic. The topic areas are pre-number concepts and mathematics learning, numeration systems and other number bases, addition and subtraction of whole numbers, multiplication and division of whole numbers, number theory, rational numbers, computers in the classroom, geometry, measurement (including the metric system), organizing/representing/interpreting data, problem solving, and diagnosis and planning for instruction.

Each class session was subdivided into three parts. First came a lecture/discussion of the topic and a follow up to any questions regarding the readings done. Next, each class had some kind of hands-on activity to introduce the students to the use of concrete materials and how to instruct children with those materials. Finally, for the last part of each class, the students were assigned specific software packages to use from the file server. The software used was the *Mathematics Concepts - Level I, Level II, Level III*, and *Level IV*, published by IBM. Specific sections of this software were selected to reinforce the lecture/discussion and manipulative parts of the class. For example, after a discussion of the use of Base 10 Blocks to teach addition and subtraction of whole numbers, and after actual hands-on exercises with those materials, the students would use one of the software packages which visually manipulated icons representing the same concrete materials.

Microcomputer Attitude Scale

During the Fall semester of 1990 two techniques were employed to measure the early effectiveness of the implementation of computers into the Elementary Mathematics Methods course. First, the Microcomputer Attitude Scale (Abdel-Gaid, Trueblood, & Shrigley, 1986) was given as both a pretest and a posttest to see if any shift in group attitudes towards computers could be detected after spending a semester using them in a class situation.

Second, a randomly selected group of students from the class were given exit interviews to determine their feelings toward the class and particularly the use of computers in that class.

The Microcomputer Attitude Scale is composed of 23 questions which focus on attitudes in five general areas:

1. The importance of microcomputers in the schools
2. The importance of programming skills
3. Teacher/student involvement (extra work load, student contact, etc.)
4. Student and teacher attitudes and anxieties toward microcomputers
5. The effect of computers on student achievement and thinking skills

The sample group of methods students in this study appeared to be quite sophisticated in their views of the importance of computers in the public school curriculum. This resulted in high positive attitudes on the pretest and no significant change in scores on the posttest for those questions. The implication is that this group of students believes that microcomputers are very important in the public school classroom and that belief did not change during the semester.

Questions related to the role or importance of programming to both students and teachers had a similar response pattern. In fact, the semester of exposure to computers and educational software served to strengthen the student concept that programming skills are not important for either teacher or student in the public schools.

Questions related to teacher/student involvement indicated two major changes in attitude. The methods students in this sample began the semester feeling that all teachers should be taught how to use microcomputers and ended the semester with an even stronger feeling that such training was necessary. On the other hand, these methods students began the semester feeling that too much attention and emphasis was being given to computer technology and that this detracted from the real problems in the schools. By the end of the semester that position had changed significantly and the methods students felt that such a detraction did not exist or that the emphasis on technology was warranted.

One of the two areas with the largest number of significant changes in mean scores was where the questions dealt with student and teacher attitudes and anxiety. The attitude of the methods students shifted significantly from the belief that both teachers and students would have increased anxiety with the increased use of microcomputers. There was also a significant shift from the pretest belief that microcomputers would not improve student attitudes toward school subjects. In addition, the methods students changed their attitude that microcomputers would decrease the amount of teacher-pupil interaction in schools between the pretest and the posttest.

The last area in which the methods students showed a significant attitude change over the semester is that of student achievement and thinking skills. The subjects began the semester feeling that microcomputers would not make better thinkers of their pupils and that standardized test scores and traditional skills would decrease. This attitude was reversed by the end of the semester after the methods students had the opportunity to work first hand with some of the available software.

Exit Interviews

Exit interviews were conducted with a group of 12 randomly selected students upon completion of the class. This group completed a brief short-response questionnaire and participated in an open-ended discussion regarding use of the computer classroom. The instructor was not present at this session to encourage students to speak freely.

The written portion included a question regarding prior computer experience which would be expected to temper students' familiarity with and use of computers in the methods classroom. The results showed a fairly sophisticated sample in that two-thirds reported using a computer at home. Half reported using the computer at least monthly, while the other six used the computer weekly or more often.

When asked how the use of the computer added or detracted from the class, all respondents felt that the computer added to their learning experience. Specifically, students mentioned that using the computer showed another way to teach and reinforce mathematics concepts covered in class, and more importantly, was a great alternative to dittos.

Students were of a divided opinion when asked if computers in the class helped their understanding of the material. While most felt that it was useful to have some experience with the different software available, they also pointed out that the concepts illustrated were things they should already have mastered. Students who already understood the concepts projected that classroom use of a computer could degenerate to 'busy work' when the novelty wore off. Still, at least a quarter of those asked believed that the software (though elementary) did provide a review of their own basic mathematics skills.

Those who got the most out of experience with the software reported using it to concentrate on the steps and process used to accomplish various learning tasks. They focused on ways these steps and processes could be imparted to new learners (both with and without computers). One mentioned that use of computers as another visual aid for presenting information was always helpful in understanding mathematics.

When asked if they could envision themselves using computers in their own teaching classrooms, all 12 said yes. A few qualified their response, hoping for a tighter integration of computers and software into other subject areas as well as for classroom management tasks. Summing up their feelings was the comment that "Computers are the future; we all need to know how to use them."

An open-ended discussion on feedback on use of the lab followed.

Highlights of comments are shown below:

1. Using computers reinforced their own learning processes and they projected that it would do the same for their future students.
2. They felt the computer work did include a component related to learning at a manipulative level because students had to push a button and it can provide tactile, auditory, and visual feedback.
3. Computers can lose their advantage when the novelty of using the software wears off or becomes predictable.
4. Students envisioned that noise could be bothersome; it was suggested that the audio effects of the software be muted in a classroom situation.
5. Computers should be used to reinforce concepts but were generally not concrete enough to introduce concepts.
6. Computers cannot replace good teaching; but should be used to reinforce learning, as a motivator, and as a reward.
7. In evaluating software, it was suggested that instead of the student teachers doing it, actual elementary and secondary students should be brought in and their responses observed. How does it work with younger learners?
8. They felt that computers and educational software should have been integrated into their curriculum earlier and integrated into their other methods courses. They reported that some students from previous semesters felt cheated in not having had computer experience.
9. They did not want to take time away from the methods classes, but suggested perhaps working with computers in a separate lab on material closely related to what was being covered in the methods course.
10. They did not feel that integrating computers into the curriculum was an added burden.
11. In terms of their future, these students knew that computers are useful, not a fad, and there is no way to go backward to pre-computer days.
12. They were definitely used to seeing computers (generally Apples) in the participating schools they were student teaching at and were interested in receiving information for funding of computers in their schools.
13. They indicated they would actively campaign for getting computers in classrooms that did not have them.
14. The role and importance of using computers with special education students was also mentioned.

Future Directions and Conclusions

After experimenting with the classroom LAN for a period of one semester and evaluating the process, some changes have been planned for the future. First, we are moving to establish model classrooms in two or three other rooms using two to four computers hooked into the network. This will give the science, social studies, and language arts methods classes access to the network in their assigned classrooms which in turn should lead to further integration into their daily teaching routines. Second, we are attempting to establish a more comprehensive electronic classroom where the delivery of instruction would be computer based to give future teachers a model of how to use the technology in the instructional setting. Finally, students will be required to use the microcomputer lab more during hours outside class and assignments will be recorded on the network itself saving time and paperwork for the instructor.

The first semester implementation of the new IBM classroom LAN has been very successful. In a period of a few short weeks student attitudes were changed significantly and in a positive direction. The mission of the project was to produce teachers who were not only comfortable with the technology, but were capable of implementing it in their own daily teaching. We believe we've come a long way in that direction in only one semester.

Reference

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Computer Inservice for Teachers of Mathematics, Grades 6-10

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During the current era of reform, mathematics teachers have special opportunities to restructure the ways that they teach their subject matter. In order for this to happen in many schools simultaneously, however, there is a critical need for teacher inservice, especially in the use of technology in teaching mathematics. This paper outlines one approach to teaching teachers how to use computers in teaching mathematics in grades 6-10.

Background for Reform

Several factors influenced the need to develop technology inservice experiences for teachers in Texas. Textbooks are adopted on a statewide basis in Texas, and the recent demand by the state for inclusion of technology into mathematics textbooks for use in high school classrooms in fall 1990 and elementary school classrooms in fall 1991 posed a critical need for teacher inservice. Too, the state's requirement that all middle school students complete a computer literacy course created a base of student knowledge about computers that can and should be taken advantage of in content instruction. Technology inservice is needed for mathematics teachers just so that teachers are as knowledgeable as students about computers.

Many national reports in the U.S. in the last few years have collectively been successful at exerting pressure for improvements in mathematics instruction. The recent *Curriculum Standards* (National Council of Teachers of Mathematics, 1989) seems to have captured the essence of these recommendations, one of which is increased use of technology in teaching and learning mathematics. For secondary school mathematics, Fey (1984) called attention to new ideas that can be taught and to new instructional techniques that can be developed using computing technology. But no similar effort seems to have been made to rethink lower level mathematics. This project was an attempt to equip teachers to understand some of the appropriate ways of using technology in teaching mathematics in grades 6-10.

Response from State Education Department

The inservice module on computers for grades 6-10 is one of a series of workshops (typically 12 hours each) that have been developed through EESA, Title II, and Eisenhower Education Act grants from the Texas Education Agency (TEA). Collectively, the modules are referred to as the Mathematics Staff Development Project; they cover virtually all of the Texas Essential Elements for mathematics in grades K-8 as well as some of the content in grades 9-12. Each module is unique, but they all share the common purpose of helping teachers teach mathematics better through the use of manipulatives, technology, and problem solving. The expectation is that this improved teaching is a necessary first step toward improved student learning.

The development of each module involves several steps; the whole cycle usually takes about a year. First, TEA chooses a contractor to develop a module; typically, this is on the basis of submitted proposals. Second, the contractor develops and field tests the module. This step takes several months. Third, TEA chooses 40 trainers for the module; these people come from all of the 20 Education Service Center regions in Texas. Fourth, the contractor conducts a conference to train these trainers. Finally, the trainers deliver the module directly to teachers. Delivery to teachers will continue for many years, since the content and instructional strategies in the modules will continue to be important, even as the Essential Elements change.

At the end of 1989, there were 24 modules (Table 1). At the outset of the Project, however, there was a conscious delay in planning for the development of the technology modules. In part this was due to the recognition that other projects involving the use of technology were in their formative stages (e.g., Ohio State precalculus project) and that the work in Texas would be more effective if we waited for information coming from those projects. It was also known that new calculators (e.g., fraction calculators) and new software were under development and that they had a strong likelihood of greatly influencing the quality of mathematics instruction.

Computers in Grades 6-10

This module was designed for grades 6-10 rather than only 6-8 in order to reach teachers of high school "general mathematics" courses with examples of the uses of technology. The two 9-12 modules involve the use of technology; but at the time of the planning of this module, it was expected that the particular uses of technology in those 9-12 modules would be too sophisticated for most general mathematics students. Thus, the 6-10 computer module was structured so as to encourage general mathematics teachers to become exposed to technology applications at levels appropriate for pre-algebra students.

The primary goal of this module is to teach teachers how to use computers in teaching the mathematics in middle school and in courses preliminary to algebra I in high school. Most middle and high school teachers have not studied mathematics with the help of computers; consequently the ways that mathematics is embodied in the materials is likely to be unusual for teachers, even though most of the mathematics is familiar in other contexts. Workshop leaders, thus, have an opportunity during presentation of this module to model for teachers how to handle a diversity of levels of understanding and confidence about both the technology and the particular embodiments of the mathematics ideas, while keeping everyone focused on the same mathematics.

One of the major differences in pedagogy between the activities participants are doing and typical textbook exercises designed for students is the chance to explore lots of examples in the technological environment. Computers can generate lots of examples quickly and accurately. These examples can provide a strong experiential base from which concepts can be developed. Without an underlying conceptual base, textbook exercises are not likely to make much sense to students; we need to take advantage of the technology to help build that conceptual base.

This workshop shows teachers how to exploit some of the unique capabilities of computers to rethink the ways that mathematics ought to be taught. If participants leave the workshop convinced that they must go back to their schools and convince their principals, mathematics coordinators, school board, and their peers about the need to acquire enough hardware and software to teach mathematics better, this module will have been very successful. In the activities early in the module, considerable help is provided for participants on what keystrokes

Table 1
Mathematics Staff Development Modules

Grade level	*Topic*
PK-2	numeration
PK-2	computation
PK-2	measurement
PK-2	geometry
PK-2	probability/statistics/graphing
PK-2	problem solving
PK-2	calculators and computers
3-6	numeration
3-6	computation
3-6	measurement
3-6	geometry
3-6	probability/statistics/graphing
3-6	problem solving
3-6	calculators
3-6	computers
6-8	numeration/computation
6-8	measurement
6-8	geometry
6-8	probability/statistics/graphing
6-8	problem solving
6-10	calculators
6-10	computers
9-12	algebra
9-12	geometry

to press and what they can expect to appear on the screen. As the module progresses and participants become more familiar with using software, this assistance decreases.

The material provided to trainers includes (a) a trainer's manual, (b) transparencies, and (c) handouts for participants. The manual includes introductory material, scripts, and blackline masters of both the transparencies and handout pages for the participants. Separate copies of the transparencies and handouts are also provided for ease in organizing the workshop. There are two versions of this module: one for Apple II microcomputers and one for IBM microcomputers. Software used is listed in Table 2.

Choosing the Mathematics to Focus On

One of the most important goals of middle school mathematics is to help students make transitions from elementary school thinking to high school thinking; that is, from concrete based thinking to more abstract thinking. The two major areas in which such transitions are needed are geometry and algebraic thinking (including work with ratio and proportion).

In geometry, the van Hiele levels of geometric thought are well researched (e.g., Fuys, Geddes, & Tischler, 1988). Students who can operate at level 2 prior to entering high school geometry are much more likely to be successful than students who are only at levels 0 or 1 (Senk, 1985). Getting students to move forward in their thinking is not necessarily easy, but it is important. Computer graphics tools can be very useful in this instructional process.

In algebra, variables and functions are clearly central concepts. There is no algebraic parallel to the van Hiele levels, but much effort has been exerted in trying to understand how students think about these ideas (e.g., Blais, 1988; Wagner, 1981). Again, improving the quality of students' thinking is not easy, but computers are ideal for generating many instances of functional relationships and for graphing those relationships. Seeing these instances and relationships ought to be very helpful for many students.

Organization of the Module

This module is divided into five sections:

1. Geometry (3 hours)
2. Visualization (3 hours)
3. Variables (2 hours)
4. Graphing (2 hours)
5. Interpreting Graphs (2 hours)

Part 1 uses the preSupposer software (Apple version

Table 2
Software for the Computer Inservice

Version	*Title*
A,I	Brett, T. C. (1988). *Building perspective* [Computer program]. Pleasantville, NY: Sunburst Communications.
A,I	Dugdale, S., & Kibbey, D. (1986). *Green globs and graphing equations* [Computer program]. Pleasantville, NY: Sunburst Communications.
A,I	Dugdale, S., & Kibbey, D. (1986). *Interpreting graphs* [Computer program]. Pleasantville, NY: Sunburst Communications.
A,I	Fish, M., & Kosel, M. (1987). *The super factory* [Computer program]. Pleasantville, NY: Sunburst Communications.
A,I	O'Brien, T. (1988). *Blockers and finders* [Computer program]. Pleasantville, NY: Sunburst Communications.
A	Schwartz, J. L., & Yerushalmy, M. (1986). *Geometric preSupposer: Points and lines* [Computer program]. Pleasantville, NY: Sunburst Communications.
I	WICAT Systems, Inc. (1987). *Math concepts: Level IV* [Computer program]. Armonk, NY: International Business Machines.
I	WICAT Systems, Inc. (1988). *Mathematics exploration toolkit* [Computer program]. Armonk, NY: International Business Machines.

Note: A denotes software used in Apple version.
I denotes software used in IBM version.

Figure 1. Sample Visualization Activities

1. a. Cut out the nine "buildings" in Figure 2. Be careful not to cut off the flaps. Your group will need one of each building.
   b. Fold each building along the dotted lines to form a four-sided tube with no ends. Tape the tube closed and fold the flaps out so it will stand up.
   c. Using the folded-out flaps as supports, tape Building A into cell A of the grid below. Then tape Building B into cell B, etc., until all nine buildings are in the appropriate cells.

G	H	M
D	E	F
A	B	C

2. a. With the grid flat on the table and side ABC towards you, lean down so your eyes are level with the table top. Consider only the heights of the buildings. When looking at Building A, is it possible to see both buildings (D and G) behind it? If not, which building(s) is(are) hidden?
   b. When looking at Building B, is it possible to see both buildings (E and H) behind it? If not, which building(s) is(are) hidden?
   c. When looking at Building C, is it possible to see both buildings (F and M) behind it? If not, which building(s) is(are) hidden?
   d. Sketch the view from side ABC.
   e. Turn the grid so side CFM is towards you, and sketch the view.
   f. Sketch the view from side MHG and from side GDA. Turn the grid if necessary.

3. a. LOAD Building Perspective. After you have read the directions, choose 3 (Play the Game) and press RETURN.
   b. The grid on the screen is a top view of a 3x3 block of buildings. At the bottom of the screen are four options. Choose "View" by pressing RETURN.
   c. The options now at the bottom of the screen are the sides from which you may view the block of buildings. Choose "Front" by pressing RETURN. Three columns of colored boxes appear.
   d. If cnly one color shows in a column what do you know about the building nearest to you? If three colors show in a column, where is the tallest building? Where is the shortest building? If two colors show in a column, what do you know about the buildings?
   e. Record the information provided in this view.

4. a. Press RETURN. You will be returned to the top view.
   b. Choose "View." Use the right-arrow key to select "Right" and press RETURN. Record the information presented in this view and return to the top view.
   c. Choose "View" and "Back." Record the information and RETURN to the top view.
   d. Choose "View" and "Left." Record the information and RETURN to the top view.

5. a. If you think you know where all the buildings are located on the grid, go on to exercise 6 below.
   b. If you aren't sure of the heights of any of the buildings, use "Remove" to temporarily hide one of the buildings so you can get more information. Record your new information. Continue gathering information until you are ready to make a prediction.

6. a. Return to the top view and select "Predict." The cell in the upper left corner of the grid is boxed. Enter the number for the color (or height) of the building which belongs in this cell. DO NOT PRESS RETURN. The highlighting box automatically moves to the next cell. Continue entering values for each building until the grid is completed.
   b. Then press RETURN to check your prediction.

7. If your answer is correct, skip to exercise 8. Otherwise, press RETURN and view the buildings again by choosing "View" and "Front," "Right," "Back," or "Left." When you are ready to make changes to your predictions, choose "Predict," use the arrow keys to highlight the cell(s) you think is(are) incorrect and enter the corrected value(s). Press RETURN to check your new predictions. If you are right this time, proceed to number 8. Otherwise, keep trying.

8. Press RETURN to get back to the main menu. Select 2 (Change Array Size). Select a 4x4 or (if you feel really daring) a 5x5 grid and play the game again.

of the module) or Geodraw (IBM version of the module) as the vehicle for teaching geometry; the approach involves a lot of constructions of figures and measuring of lengths, angles, and areas. Part 2 is spatial visualization; activities built around software are supplemented with manipulative activities. Part 3 is a study of variables through programming. Part 4 uses graphing software to investigate properties of graphs of functions. Part 5 deals with reading information from a graph to become more flexible in the use of graphing concepts.

Two specific examples of activities in the module are given below, one on geometry (Figures 1 and 2), and one on graphing (Figure 3). The geometry example shows how off-computer and on-computer activities can be combined, and the graphing example shows how on-computer activities can be adapted for off-computer mode.

Developing Parallel Versions

For a variety of reasons, both Apple and IBM versions of the module had to be developed. In most instances, the same software was used in the two versions. We expected, therefore, that little editing of the supporting print materials would be necessary. However, in one case, there seemed to have been a significant shift in the menu structure programmed into the two versions; it seemed

Figure 2. Buildings to Cut Out

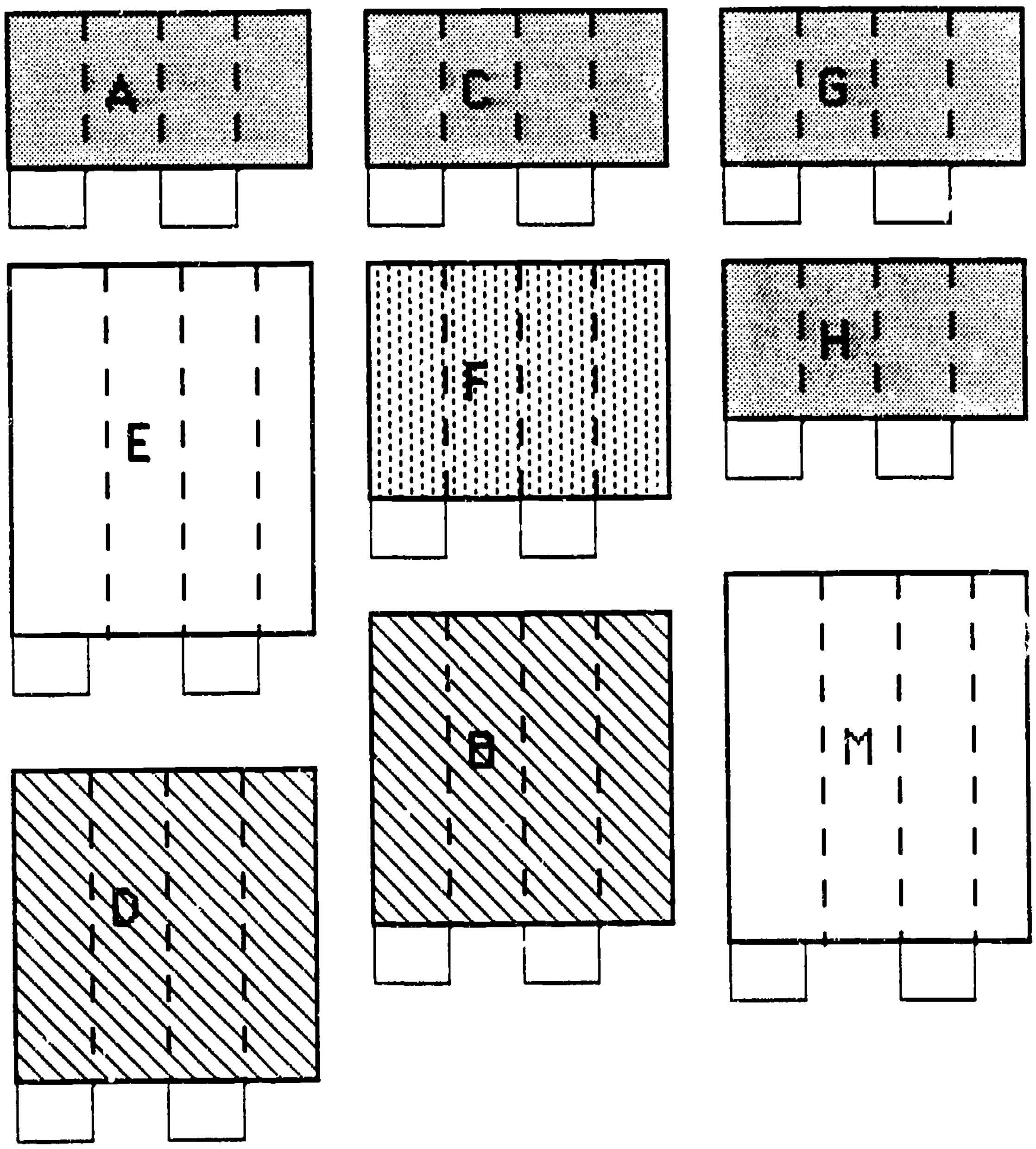
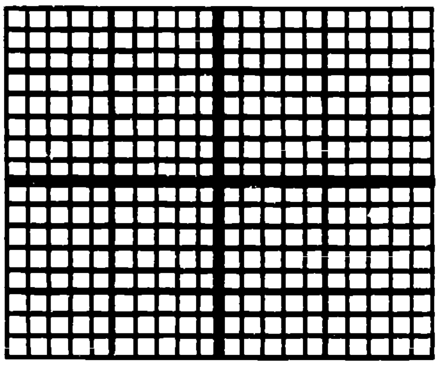


Figure 3. Sample Graphing Activities

1. a. Solve the following equation like you did in high school algebra. Write out all the steps.
   $6(x - 4) = -2(x - 3) + 2$
   b. LOAD Green Globs and Graphing Equations. Using the menus and screen directions, choose Equation Plotter and then Rectangular Grid.
   c. Use the program, Equation Plotter, to graph the left side and the right side of the original equation. Sketch the graphs on the grid below. What are the coordinates of the point of intersection?



   d. Circle the middle step in your solution in part a. Clear the grid on your screen (type ESC) and then use the software to graph the left side and the right side of that equation. Sketch the graphs above. What are the coordinates of the point of intersection?
   e. Circle the last step in your solution in part a. Use the software to graph the left side and the right side of that equation. Sketch the graphs above. What are the coordinates of the point of intersection?
   f. What do the three points of intersection have in common?

2. a. Graph all the equations below on one grid. Describe how the graphs are related.

$y = x + 2$	$y = x + 3$	$y = x + 4$
$y = x + 12$	$y = x - 5$	$y = x$

   b. Clear the grid, and graph all the equations below on one grid. Describe how the graphs are related.

$y = 2x$	$y = 3x$	$y = 7x$
$y = 0.1x$	$y = -3x$	$y = -1.2x$

   c. Clear the grid. Graph all the equations below on the same grid. Describe how the graphs are related.

$y = 2x + 3$	$y = 5x + 3$	$y = 0.2x + 3$
$y = x + 3$	$y = -3x + 3$	$y = 0x + 3$

   d. In the general equation, $y = mx + b$, what happens to the graph as m changes? What happens as b changes?

3. a. Write a definition of variable.
   b. Does your definition apply to x or y in the equation, $y = mx + b$? Why?
   c. Does your definition apply to m or b in the equation, $y = mx + b$? Why?

that when the second version was programmed, improvements in the authors' thinking about the software were incorporated, without those same improvements also being written into the first version. These changes required very careful editing of our materials to be sure that what the participants saw on the screen matched the written materials.

We want to encourage software companies to give careful thought to the lack of parallelism inherent in software written for two different machines. We contend that software will not be effectively used in schools without excellent support materials to accompany that software. That support material may or may not be written by the software company. For example, all teacher educators are now in the position of (potentially) helping teachers learn to use software in their classrooms. Teacher educators must obviously talk to teachers in terms of the machines that the teachers have available to use. When time is spent learning how to inservice teachers on a particular piece of software, it is frustrating to have to recreate a different inservice program for each version. It is also frustrating for teachers when our suggestions don't work because of differences in the versions. Life would be easier if software companies would either create truly parallel versions or highlight the differences in the reference manual so that no one is surprised.

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Footnote

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Integrating Technology into Secondary Mathematics

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In the past few years a revolution in mathematics education has begun. The volume of recent reports decrying the mathematical literacy in this country are a damning indictment of our traditional way of teaching (e.g., Dossey, Mullis, Lindquist, & Chambers, 1988; National Research Council, 1989). The normal classroom routine of homework check, teacher lecture/demonstration, and work on new homework has been revealed as uninteresting and ineffective. In this type of class, students learn to memorize bits and pieces of concepts and skills, but do not internalize or generalize the information. It is no wonder that so many American students are "turned off" to mathematics.

The *Curriculum Standards* (National Council of Teachers of Mathematics, 1989), designed and approved by mathematics teachers nationwide, presented a bright and promising alternative for teaching mathematics. Based on the principles of cognitive psychology, the underlying theme of the *Standards* is constructivism. Briefly, this means that in order for an individual to understand a concept, he or she must actively experience it and then internalize it and construct a personal cognitive representation.

This model of mathematics instruction emphasizes a problem solving atmosphere in the classroom. Students should investigate problems in the context of realistic models. Individually and in small groups, they should be given an opportunity to explore, to conjecture, to test and to generate ideas and solutions. In this manner, they will be able to actively experience the mathematics and to construct their own internal concepts.

In the high school algebra curriculum, one major recurring theme is equations. Students work in solving and describing many and various equations. To model an equation, to actually experience it, a graph is appropriate. In the traditional classroom, students spend considerable time and effort in the mechanical aspect of drawing a graph of an equation. By the time they have a "pretty" representation, they usually have forgotten the concept. When the student is able to input an equation and immediately see a graphic representation, they are free to concentrate on understanding the representation and the underlying concepts. The graphing calculator provides this capability. The particular model used in these examples is the Casio fx 7000-G, but similar models are available from various companies. The student types in an equation (linear or non-linear), and at the touch of a key it is represented graphically on the display. It is easy to overlay several equations to make comparisons. For example, students may visually examine the graphic difference between two equations whose only difference is the constant term. While several computer programs (notably the classic *Green Globs and Graphing Equations*) also perform similarly, they are not as portable or as easy to use as the handheld calculator.

In geometry, students are often buried in the nether world of memorizing theorems and proofs, and never have an opportunity to experience geometry. Construction problems, similar to algebra graphs, often become more artistic endeavors than mathematical models. A series of computer programs called the *Geometric Supposers* (available from Sunburst) is an excellent tool to simplify this experience. Four *Supposers* are currently available: the *preSupposer* (points and lines), *Triangles*, *Quadrilaterals*, and *Circles*. The samples presented below used the *Geometric Supposer: Triangles*. This tool provides a geometric "microworld" where the computer can construct a geometric figure with as little or as much input as the student desires. The student may request a right triangle, or specify the sides and angles to draw a specific right triangle. He or she may then draw various constructions (segments, altitudes, etc.) on the figure and measure and compare any length, angle, or area measure. For example, a student may construct a right triangle and then measure the sides to verify or discover the Pythagorean Theorem.

While these technological tools have been widely discussed and recommended (Barrett & Goebel, 1990; Dion, 1990; McCoy, in press; Thompson, 1989), there are many mathematics educators who agree with their use in theory but just can't quite picture how to integrate them into classes. This is true of both preservice and inservice mathematics teachers. In order to facilitate easy integration, teachers must understand how these tools can allow them to teach in a more efficient and effective manner. The following lessons utilizing these tools were planned and successfully implemented by mathematics student teachers.

Algebra Lesson Plans Using the Graphing Calculator

Algebra Lesson 1

Objective. Given an equation of a line, student will be able to determine the effect of the slope on the graph.

Learning Activities. The teacher demonstrates the graphs of the following four equations:

$y = 1/3\,x + 2$
$y = -1/3\,x + 2$
$y = 3\,x + 2$
$y = -3\,x + 2$

Students break into small groups to graph given sets of similar equations. The teacher then leads the class in discussing in words how the slope affects the graph.

Algebra Lesson 2

Objective. Given a parabolic equation, student will be able to describe the general characteristics of its graph.

Learning Activities. Students are given a basic equation of a parabola, y = xSUP 4(2) , and asked to produce its graph on the graphing calculator. Students are then asked to experiment and generalize to describe the effect of the following changes in the equation:

1. Negative coefficient (inverts parabola to open downward)
2. Whole number coefficient (narrower as it becomes larger)
3. Fractional coefficient (wider as it becomes smaller),
4. Adding a positive constant (moves vertex up)
5. Adding a negative constant (moves vertex down)

Algebra Lesson

Objective. Student will be able to describe the solution sets of systems of simultaneous linear equations in two variables.

Learning Activities. Students are given pairs of linear equations in two variables (with one solution), They graph each set on the graphing calculator and identify the solution (point of intersection), estimating when necessary. They are then challenged to find pairs of equations for which there is no solution (remind them that they must consider intersections which may occur off the scale) and pairs of equations which have an infinite number of solutions. After sufficient time for experimentation, the teacher leads the class in a discussion and description of the three possible types of solution sets.

Algebra Lesson 4

Objective. Student will be able to identify the local minimum and/or the local maximum of a function using the graphing calculator.

Learning Activities. Teacher demonstrates how to enter a range and a function into the calculator, and then use TRACE to display the x or y value of the function at a given point selected by the user. To determine the relative maximum of y, the student moves the selected point along the graph checking for the largest value of y. Students then find the relative maximum and/or minimum for a given set of functions.

Geometry Lesson Plans Using the Geometric Supposer

Geometry Lesson 1

Objective. Student will be able to use the converse of the Pythagorean Theorem to determine whether a given triangle is a right triangle.

Learning Activities. Following a discussion of the Pythagorean Theorem and its converse, students generate random triangles on the *Supposer* (using the Create Your Own option and entering random lengths of sides). Students then conjecture from sight whether the triangle is a right triangle, and check by measuring the sides and checking whether the sum of the squares of the two shorter sides equals the square of the longer side.

Geometry Lesson 2

Objective. Student will be able to identify and describe angle bisectors and medians of various types of triangles.

Learning Activities. The teacher gives definitions and uses the *Supposer* to show examples of angle bisectors and medians. Students use the *Supposer* to construct an obtuse triangle and draw one angle bisector and one median. Students then measure angles and lengths to verify that these constructions satisfy the definitions. Students then independently experiment with isosceles triangles and state their conclusions about the medians and angle bisectors. They should discover the following: The median to the base of an isosceles triangle is also a perpendicular bisector.

Geometry Lesson 3

Objective. Student will be able to test and verify the following corollary: The length of the altitude drawn to the hypotenuse of a right triangle is the geometric mean between the lengths of the segments of the hypotenuse.

Learning Activities. Students construct a 3-4-5 right triangle in the *Supposer* using the Side-Angle-Side construction. They then draw an altitude through vertex A, and measure each side to check whether BD/AD = AD/DC. Independently, students then use several *Supposer*-generated right triangles to test the corollary (measures will be approximate). At the end of the lesson, the teacher asks if anyone found instances where the corollary did not hold true. The teacher emphasizes that this activity involves testing the corollary, rather than formal proof.

Geometry Lesson 4

Objective. Given a triangle, student will be able to compute the sine, cosine, and tangent of a certain angle using the measurements of the sides.

Learning Activities. Students, working in pairs, use the *Supposer* to draw a right triangle, measure the sides and angles, and determine Sin (opposite/hypotenuse), Cos (adjacent/hypotenuse), and Tan (opposite/adjacent) for each angle. Data are recorded on a worksheet, and calculators can be used after measures are obtained. Students repeat these steps for three right triangles. The teacher then introduces tables and/or scientific calculators as a quick way to obtain the same trigonometric values.

Summary

All of the above lessons incorporate the active involvement philosophy of the *Curriculum Standards*, with a goal of student understanding of the concepts. These sample lessons illustrate how various topics can be more efficiently and effectively taught using technology tools within the traditional mathematics curriculum. These examples should be useful in guiding mathematics educators as they design a wide variety of secondary mathematics lessons which integrate technology tools such as the graphing calculator and the *Geometric Supposer*.

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Statewide Inservice on the Use of Computers in Teaching Mathematics in Grades K-10

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As our knowledge about effective instruction continues to increase, there is a constant need for teacher inservice in many areas. In mathematics in particular, technology is becoming more and more central to effective instruction, both for delivering standard mathematics in better ways and for introducing new mathematics to the curriculum. Since most teachers did not have any exposure to technology in their preservice preparation, technology inservice is almost to a crisis stage; students are frequently more knowledgeable about technology than their teachers.

The goal of this project was to provide inservice education throughout Texas for mathematics teachers in grades K-10 by extending the impact of technology inservice programs already prepared with federal funds under the direction of the Texas Education Agency. To achieve this goal the project (a) delivered these inservice programs to a wider audience of teachers than was possible with existing funding, (b) created short inservice programs for delivery to school administrators and school board members, and (c) created a guide on conducting technology inservice programs for mathematics teachers. The choice of school board members as one of the target groups was driven in large part by the critical role that they play in the implementation of curriculum innovations by providing the support necessary for teachers to actually deliver innovations.

Background for Reform

Beginning in 1986, the Texas Education Agency (TEA) has supported the development of teacher inservice modules (typically 12-hour workshops) focused on the use of manipulatives, concept development techniques, and problem solving applications to enhance the teaching of the Texas Essential Elements for mathematics. These modules were developed by contractors using Education for Economic Security Act (EESA), Title II, and Eisenhower Education Act discretionary funds retained by TEA for improvement of mathematics instruction. By the end of 1989, 19 modules had been developed to help teachers improve instruction on mathematics content. As a complement to these modules, TEA also contracted for development of five modules dealing exclusively with the use of technology: PK-2 Calculators and Computers, 3-6 Calculators, 3-6 Computers, 6-10 Calculators, and 6-10 Computers. The calculator modules use calculators capable of performing fraction operations and integer division. The computer modules range from examination of software to demonstrations of coherent instruction on geometry and spatial visualization. (More information on the process of development of the modules and on the content of the computer modules is provided in the paper, "Computer Inservice for Teachers of Mathematics, Grades 6-10." Specific information on the calculator module is contained in Bright, Lamphere, & Usnick, in press.)

Once a module is completed, its authors train 40 specialists selected by TEA from all parts of Texas: at least one specialist comes from each of the 20 Service Center Regions. Trainers receive information on both the content of the module and techniques for delivering the module to teachers. At the end of the training each trainer receives a trainer's manual (which includes hand-outs for teachers, overhead transparencies, instructions for delivery of the module, and background information) along with a kit of manipulatives or access to software sufficient to deliver the workshop to 36 teachers. Each trainer makes a commitment to deliver the module at least three times; the delivery might be (a) at the request of a specific school district for its own teachers, (b) by a university as a summer workshop for teachers, or (c) through a Regional Service Center or county department of education. The plan for training of the trainers provides standardized exposure to the information in the modules in order to assure that the teachers in the subsequent workshops will all receive the same general exposure to the use of manipulatives and technology.

The only drawback in this plan is that trainers are not authorized to train any more trainers. The burden for providing inservice to teachers on any single module is squarely, and continuously, on the shoulders of these 40 trainers without providing any plan for giving relief from demands from school districts to deliver the inservice workshops. Further, the TEA plan does not address the role that administrators or school board members might play in the actual implementation of the use of manipulatives and technology in the teaching of mathematics.

Finding philosophical support for the technology modules from teachers, school administrators, and the general public presents somewhat of an obstacle. It has become apparent, for example, that considerable concern exists among these groups, especially relative to the use of calculators in the classroom. Use of computers, on the other hand, is often viewed as improving the quality of mathematics instruction. The TEA technology modules are intended to communicate that technology needs to be used to facilitate the teaching and learning of mathematics. Given the strong support from the *Curriculum Standards* (National Council of Teachers of Mathematics, 1989) and earlier national reports for the inclusion of technology in teaching mathematics, it is important that teachers understand how to use technology in their teaching. The immediate support needed for teachers is the modeling of uses of technology that could be applied directly to teaching. The TEA technology modules do this.

Project Overview

To help speed the dissemination of the computer modules, the University of Houston received funding from the national programs component of the Dwight D. Eisenhower Education Act in the U. S. Department of Education to conduct a training project to increase the number of trainers for the technology modules and to develop an inservice plan for school board members and school administrators to improve the likelihood that the instructional techniques suggested in the modules will actually be implemented in classrooms. (Texas law requires school board members to receive a minimum amount of inservice each year.) This project was carried out in three parts.

First, a six-hour module on the use of calculators and computers in teaching mathematics was developed for school administrators and school board members. The module includes both demonstration and hands-on work with computer software, as well as discussion of applications of computers across content strands and grade levels. Specific examples from the existing teacher modules are included. A short videotape was also prepared to show students using technology during mathematics instruction. This module carries school board training credit and was written by Clarence Dockweiler and Jane Schielack at Texas A & M University with a subcontract from the University of Houston.

Second, a guide was developed on effective ways of providing technology inservice for mathematics teachers. The guide contains information on how to help teachers overcome their "fears" about the use of technology and information on the ways that technology ought to change the context of mathematics instruction. This guide was written by George W. Bright, Patricia Lamphere, and Virginia E. Usnick at the University of Houston.

Third, training was provided for 50 "supertrainers" (25 from grades PK-6 and 25 from grades 6-10) on all of the technology modules for teachers at the relevant grade levels. Each supertrainer is designated as a "trainer of trainers" and is in the process of developing a plan for training 15-20 "ordinary" trainers for the calculator and computer modules for the appropriate grade levels. Each of these ordinary trainers, in turn, like other trainers who participate in the TEA mathematics inservice project, must agree to offer the calculator and computer modules at least three times.

The first cycle of training by supertrainers was completed in August 1990. About 150 people were trained to deliver the modules. However, with new textbooks for grades 1-8 moving into classrooms in Fall 1991, it is expected that there will be a second cycle of training of trainers needed in Summer 1991. Even so, if each of these 150, plus the 50 supertrainers, conducted workshops for an average of 20 teachers during 1990-91, the supertrainers project would directly impact about 4,000 teachers in Texas on the use of calculators and computers in teaching mathematics. (There are over 100,000 teachers in Texas who provide instruction on mathematics in grades K-10.) This is of course in addition to training conducted by the original trainers.

Evaluations of Training Sessions

The reactions of both supertrainers and ordinary trainers to the modules has been uniformly positive. One big hurdle in getting computers used in classrooms seems to be in having teachers design activities for use with students. The modules provide clear examples of activities that are effective with students; most activities for participants can be taken almost directly into classrooms. After trainers work through these examples, they seem to have an "aha" experience in terms of "Now I know what to do with computers!" Those trainers are then able to extend these examples into coherent curriculum plans that they can pass on to teachers.

Activities are often structured for pairs or small groups of participants, with repeated requests for explanations of thinking (consistent with the communication component of the *Curriculum Standards*). Indeed, the module activities encourage participants to engage in discussion to convince other members of their small groups of the appropriateness of particular processes used in solving a problem. Trainers are often surprised that these group activities seem "quieter" than expected and are encouraged that teachers can relatively easily be convinced both to use small groups and to expect students to justify their work.

Participants in the workshops delivered by trainers are often surprised at the mathematics content they learn through the activities. Comments such as "I didn't know that." or "I wonder if this is always true." or "I never thought of it that way before." or "What would happen if ..." are often heard. Like trainers, participants seem surprised that so much learning can take place when small groups are used. It is not unusual for the workshop leader to have to entice the small groups to come back together and stop sharing ideas individually so that sharing can be done with the whole group. The excitement and enthusiasm generated by teachers' active involvement in learning seems to be carried over into their classrooms.

The schedule for completion of this project also meshed nicely with the schedule for adoption of new K-8 mathematics textbooks in Texas. The textbook proclamation for those books was finalized in March 1989, with textbooks delivered to the state adoption committee by May 1990. The list of state adopted textbooks was compiled by late 1990, so that new textbooks could be used in schools beginning in Fall 1991. The training of teachers resulting from this project began during 1990-91, so that as teacher committees selected new books in Spring 1991 from the state adopted list, many teachers had backgrounds in the use of technology in teaching mathematics. If these teachers served on selection committees or as resource persons to assist selection committees, the result ought to have been a better evaluation of the quality of textbooks that are under consideration. Hopefully textbooks were chosen that better incorporated technology in instruction.

National Significance

The plan in this project for training teachers to use the technology modules is one that could be applied in other places. No single project can hope to educate a majority of teachers directly. Rather, projects must set in motion a series of events that will ultimately result in improved instruction in classrooms over a large geographic area. The use of supertrainers to train other trainers, with all trainers committed at the outset to working directly with teachers, is a very powerful scheme that has been used effectively before on a smaller scale. This project demonstrated that this model can be applied effectively on a statewide level, with participation from all geographic areas of Texas. The sharing nationally of the outcomes of this project can be expected to serve as a catalyst for further inservice on technology in teaching mathematics in other states.

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Footnote

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Section Editor: Marianne Handler

MANAGEMENT

Masses of information come across the desks, and the disks, of school managers, administrators, and teachers. The computer has long been thought of as a tool for managing that information, for reducing the time needed for the complex and tedious tasks of collecting and analyzing necessary data. Computerized information systems designed to solve the needs of specific and complex data collection processes are seen in more and more universities and schools throughout the country. The development of these computerized information systems requires long term planning and revising as well as the involvement of those persons whose work will be most affected.

In this section Geroge Fero of Northwest Missouri State University, Barbara Hakes of the University of Wyoming and Lynn Heinrichs and Rita Noel of Western Carolina University have looked more closely at the managerial power available to us through technology. Two of the authors have described ways in which the computer solves problems at a university wide level as well as at the level of the individual faculty member. Our third author describes an equally valid use of the technology at the local school district level and also provides food for further thought by addressing some of the problems that still need to be solved as technological capabilities increase.

Fero describes the steps taken when major state restructuring of the teacher accreditation process included extensive new reports from teacher education institutions. The ability to use available and powerful campus computing facilities to combine new required data with previously collected data is a fine example of the computer as a management tool benefiting all parties. The state-required information allows teaching faculty, student advisors, and the students themselves immediate access to necessary information. Fero offers a successful experience as a model for other institutions beginning to look at their own information systems.

The difficulty of individualizing large class sections at the university level is addressed by Henrichs and Noel. They have used a hypertext program to develop a local solution. The linking capabilities of the program were their key to designing a program which would solve the management component of tracking individualized student contracts. Within the transparent frame they are able to keep track of all five elements of each contract. The management issues of saving time, analyzing data, and printing reports for students have been solved by using a more recent technological tool, hypertext, to attack a long term management problem.

In the last of the three articles Hakes describes the way in which computers are used for record keeping and assessment of the testing taking place in schools across the country. She describes a very specific situation where teachers learn to use the University Instructional Management System to assist them in monitoring student mastery. The measurement issues she addresses in describing her project are not unlike those taking place throughout the country. There is a need for the computer as a management tool to collect and analyze the great amounts of data being amassed. She also expresses concern about the level of cognitive skills being measured and the need for new and different test bank items and ways in which the computer can be a tool in analyzing them.

Technological advances will continue to improve the ways in which information management systems can be designed. The need for creative approaches to developing the system that can best do the job will continue to be the key to success. Working in teams stressing on-going communication and creative collaboration, individuals who will use the systems and those who will design the systems must take advantage of the state of the technology in developing new and innovative management solutions.

Application of Computing Services in Tracking Preservice Teacher Education Students

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The Missouri Excellence in Education Act of 1985 provided for a major restructuring of the preparation of teachers in Missouri including major changes in the certification process and manner in which teacher education programs were governed (Ryan, 1989). Before the 1985 act, eleven institutions in the state were able to determine their own requirements for teacher certification and issue teaching certificates independent of the Missouri Department of Elementary and Secondary Education (DESE). The Excellence in Education Act placed all responsibility for teacher education programs and certification with the Missouri State Board of Education, represented by DESE. Included in this was the need for all teacher education programs to be approved by the Board of Education.

Since 1985, Missouri colleges and universities with teacher education programs have been adjusting their requirements to the state program approval process. The state approval process enables those institutions to recommend graduates for teacher certification and the state issues the appropriate teaching certificate or endorsement. This approval process, with its in-depth evaluation, has resulted in one college losing its ability to offer any teacher education programs, and the loss of individual programs at other institutions. One important component found throughout the 32 standards that the colleges and universities must meet that has had an impact on the process, is the need to maintain in-depth records on the progress and qualifications of all teacher education students (Missouri 1986). Records which need to be kept on each student include: results of three major standardized tests (ACT, C-BASE, NTE); grade point averages; specific records dealing with all pre-student teaching clinical experiences; application for admission to professional program; student teaching records; initial certification; and initial placement information. Most of the content of these records must be kept indefinitely. Direct access to some information contained in the files is required for two years following graduation to service the required Beginning Teacher Assistance Program, also enacted with the 1985 act. In order to address the record keeping requirement, along with other responsibilities, the College of Education at Northwest Missouri State University established the office of Teacher Education Student Services (TESS).

Teacher Education Student Services

The TESS office was charged with tracking teacher education students and maintaining records for those students in the areas of pre-student teaching clinical and field experiences, entrance and exit testing, extended student teaching, certification and the Beginning Teacher Assistance Program. One major purpose of the TESS office was to ensure that the University was meeting all record keeping requirements of the state approval process. The Coordinator of Teacher Education Student Services identified the resources needed to accomplish this task, and decided that the complexity of the issue appeared to require more than a simple file folder for each student. The TESS Coordinator determined that the use of a computer data base was needed to track teacher education students.

Computing Services at Northwest

Since August 1987, Northwest Missouri State University has had the distinction of being called an "Electronic Campus," with every dormitory room and faculty office equipped with a terminal connected to the university's VAX. In addition there are traditional computer labs on campus. Every authorized user has full access to computing services such as electronic mail, university directories, word processing, spreadsheets, scheduling information, electronic news, library catalog, encyclopedia, and statistical packages. The computer system has recently been expanded to include voice mail, and student access to transcripts and billing information. By the 1991 Fall semester all students will be able to schedule classes for the 1992 Spring semester from any terminal on campus.

Planning for the TESS Project. With the availability of the university VAX the computer services needed to address the records problem appeared to be available. The TESS Coordinator worked with university computing services to determine the feasibility of applying the university computer system to the task. It was decided by the academic computing staff that a data base tracking program needed to be developed specifically for the TESS Office that would maintain a record of the contents of student files, and also access active and inactive student records. This avoided duplication of records, providing for the most accurate information to be available at any time, and protecting valuable disk storage space. Except for College Basic Academic Subject Examination (C-BASE) scores, National Teacher Examination (NTE) scores, and information on available documentation for each student, all other data on teacher education students were already maintained somewhere in the university system. An analysis of what was required, and how to access that information was conducted by the TESS Coordinator and a Senior Programmer with computing services. It was determined by Northwest Computing Services that the TESS Records System be maintained on a VAX with restricted user access, but with the capability of linking with other VAXes on campus to allow for information sharing. This allowed for the security of student records, while enabling some information to be available to authorized users as permitted. It was decided that the TESS Records System be accessible only from the TESS user account or by users with privileged accounts, thus it was located on Northwest Node 3, the administrative VAX accessible only from terminals with a direct line. Five terminals in the College of Education at Northwest were given this access.

TESS Records System

The first phase of this project has been completed. This involved writing the initial file maintenance program, developing programs to produce selected reports as needed, and entering initial data for over 1600 teacher education students and graduates. The TESS File Maintenance Program was written in COBOL and accesses all active and inactive student records ensuring accuracy in name and address changes. Access to the TESS Maintenance Program allows the user to input test score data for the C-BASE and NTE for each student, and documentation of acceptance to professional program, student teaching, evaluations, certification and initial job placement. Every document placed in the student's file folder is noted in the student database. The first screen of the File Maintenance Program allows access to individual student records either by last name - first name - mi, original last name, or social security number (SID). The second screen displays the student's advisor, majors, minors, degree program and ACT scores and does not allow data input. Beginning with the third screen, TESS personnel may input data. This screen displays and allows entry of C-BASE scores, admission to teacher education information, and speech assessment information, while the next screen displays and enables input of NTE scores, documentation that student teaching evaluations, certification and initial placement information is on file. Additional screens display course numbers of those undergraduate and graduate professional education courses that require specific documentation to be maintained including the course grade and documentation is on file in the student folder.

The TESS Reports Program uses FOCUS Version 6.1 for VAX/VMS (1990) a fourth generation language for report generation. The menu generated reports include: 1. Course Enrollment; 2. Advisors Listing; 3. Student Teacher List Processing Document; 4. Course Grade - Document on File; 5. Course Grade Listing; 6. Application for Admission to Teacher Education; 7. Estimate of Graduating Students. These reports are able to produce a complete "Application for Admission to Teacher Education" for all students eligible for admission to advanced study in education, reports of ineligible students enrolled in selected courses, lists of advisees admitted to professional program by advisor, estimates of students planning to student teach in any semester, as well as mailmerge and list processing capabilities. Special reports using any other available data in TESS Records System and other data bases are available within twenty-four hours through computing services

An example of the necessity for these reports is the need to be aware of students who fail to meet the Missouri "C" rule that will require that all course work in professional education be completed with a grade of C or better when implemented in the Fall of 1991. The Course Grade Listing report generated by the TESS Reports Program produces a list processing document that can be used to generate letters to affected students and their advisors on a semester basis. This ensures proper notification is given to students needing to supersede grades of D or F. Having the capability to generate such reports and documents on demand enables timely notice of existing deficiencies and allow affected teacher education students to remove the deficiency, or perhaps if enough deficiencies exist, select an alternative to teacher education. User access to File Maintenance and Reports is menu guided. All data input are completed on a continuous basis by the graduate assistants assigned to the TESS Office. While the TESS Records System is a user friendly menu generated program, the FOCUS program is sensitive to upgrades. Often, when other software accessed by these programs is upgraded, adjustments need to be made by the programmer to meet the specifications of the upgrades. The second phase of the project will involve further refinement and application of the data base system and report forms. For example, because test scores such as the NTE are also now being used by the university in the assessment of programs, score reports on magnetic media are being purchased to enable additional data to be accessed by authorized users. When this is completed, those scores will be accessed directly by the File Maintenance Program eliminating the need for manual data input in the TESS office. In the past C-BASE scores required by Missouri for admission to professional programs have only been reported to faculty advisors upon request. Those scores will soon be available through the transcript maintenance program, and will be displayed when the student transcript is accessed by either the student or advisor.

Future Implementation Plans

Phase II also will mark the implementation of a long range file maintenance program. It has been determined that regular purging of "paper" files is necessary and a program is being developed that will generate a report of files that should be moved to either inactive or archive status. In addition, since data storage capacity does have limitations, this program also will reduce the size of the TESS record for each graduate or inactive student by maintaining only those data that must be maintained indefinitely. One problem that has been identified and still needs to be addressed concerns the identification of baccalaureate graduates who have returned for graduate work. There is a need to continue the records of these students through the graduate program that may take up to 8 years. Initially the purge program was designed to delete records two years following graduation or last enrollment. A graduate student may have gaps in enrollment exceeding two years. Therefore, the program has to be adjusted to be selective when graduate student records are encountered but not require extensive review by TESS personnel for exceptions.

The implementation of the TESS Office and Records System has had an impact on teacher education programs at Northwest. Before the implementation of the TESS Office and development of the TESS Records System, teacher education records were kept in at least five separate areas. One result of that was the inability of faculty to get a full picture of the progress of teacher education students, and the potential problems that existed in the newer process and requirements leading to teacher certification. Now all records for each teacher education student are found in one central location. Because of the broad access of the TESS Records System, student and faculty questions about student progress are more readily answered. In addition, when necessary, selective notifications can be made to specific groups of students through the ability to generate mailing lists that meet specific criteria based upon data contained in the TESS Records System. For example, students who plan to student teach during the next semester are able to be identified and subsequently notified of the need to submit student teaching applications for the coming term. The ability to be selective in making such a mailing reduces unnecessary expenses for this activity by nearly fifty percent. By being able to identify where students are in their degree programs, dissemination of important changes, deadlines, and other information is directed to those most affected in a more timely and efficient manner. However, the data required to do this is often self-reported, for example, student teaching semester, name changes, and address changes. We have found that students and faculty need to be reminded at least once per semester to submit necessary updates to either the TESS office or registrar depending upon the nature of the change.

As states continue to react to the teacher education reforms called for during the past decade, the standards for certification in the teaching fields continue to change. In addition, various accrediting agencies, state or otherwise, have placed increased emphasis on the need for increased documentation of teacher education students and programs. This need for documentation along with the complex standards that need to be met by each student are requiring colleges and universities to find the most efficient means possible to do the job. While computers have been used by colleges and universities for research, finance and records keeping, these colleges and universities need to develop increased use of available resources to enable broader application of computer systems in tracking students, specifically teacher education students.

The TESS Records System is an example of how one university was able to use its resources and imagination to develop an interactive program that allowed shared utilization of student records and university resources. While still in its early stages, this system is a beginning working model that may be adapted to fit needs and application of other teacher education institutions. Individually developed programs such as the Northwest TESS Records System demonstrate the application of university computing services to track the progress of teacher education students in meeting the needs of the university, the state and above all, the student.

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All Students Can Learn; and Teachers Do Make A Difference: A Computerized Instructional Management System

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Significance and Need for an Instructional Management System (IMS)

This paper has particular significance at this time because the performance base of educational systems nationwide is changing from a compliance system to a process and outcome based system (Andrews, 1989).

Change from Compliance to Process and Outcome

Educational systems at both the K-12 level and higher education have for years been accountable for compliance to rules and regulations; measuring their performance on number of students produced, annual SAT, MAT, CAT, or other aggregate norm-referenced test scores. Such measures are equivalent to measuring the performance of a business based on gross annual sales. The bottom line is not gross sales but net profit (Hakes, Andrews 1990).

The concept of net profit in education was set-forth in 1986 by Andrews and his associates at The University of Washington. This concept has become known as "value adding" through the process of schooling. Value adding is accomplished by measuring the entry-level performance of students, following those same students as they progress through the schooling system, and measuring each student against him/herself.

The outcomes expected of schools have tended to focus on lower level cognitive skills and on norm-referenced tests. This practice seems to have been the result of historical use and lack of availability of advanced levels in both hardware and software to assist school personnel in using criterion-referenced testing and testing of other domains such as creativity, high order thinking skills, problem solving, applied science, and technology.

IMS Hardware

The College's IMS laboratory and link with Campbell County and the Gillette Schools consists of the following: a modem, a remote emulation kit, an NCS scanner, an IBM computer, a laser printer and an image projection system. The College's laboratory school, The Wyoming Center for Teaching and Learning at Laramie (WCTL-L), has already trained many of its teachers in this laboratory.

IMS Software—Description of Capabilities

The primary purpose of the IMS is to assist teachers in monitoring student mastery. A description of the IMS is summarized here from the Campbell County School District's IMS manual (Weber, 1989). There are five general parts to the IMS. These are:

1. Curriculum Development
2. Norm-Referenced Testing
3. Test Item Bank
4. Criterion-Referenced Testing

5. Reporting and Record Keeping

Gillette is using an ongoing curriculum alignment process. This process includes defining what is to be taught, encouraging effective instruction, and testing what has been taught. A data-driven decision-making process for teachers and administrators is supported by the reports generated from the IMS.

Two forms of district-wide testing are used:

1) norm referenced; the MAT6 test battery is administered to all students in grades 1-12 each spring. The results from this battery are used by the District to monitor the success of its students compared to students throughout the nation.
2) criterion-referenced; these tests are being developed and implemented in several areas. Reading and math are emphasized in the primary grades. These areas are followed by science, language arts, social studies and spelling. The results of these tests are used to evaluate the success of student mastery of the District's curriculum.

The IMS is designed to clearly define the District's expectations of student mastery and to provide teachers with a number of reports to assist them with effective decision-making.

The Wyoming School/University/Business Partnership, through the Gillette Schools and a partnership with IBM, is undertaking further development of the IMS. As the District generates criterion-referenced items for additional subject areas at lower order levels, the WCTL-L in the College of Education at The University of Wyoming is conducting research and development to add higher order skills to the IMS for the aforementioned subject areas. Ultimately, the goal is to develop a statewide data base and IMS.

Improvements Needed in the IMS

Through an informal assessment of the IMS, it appears that teachers presently feel too much of their time is required for testing. This is a problem the WCTL-L and The College of Education's testing specialists are addressing. Additionally, as previously mentioned, the present criterion-referenced items assess only lower order thinking skills. Again, this is an issue that will be addressed through the Partnership. Teachers also feel the IMS needs to be more user friendly and require less training time. Again, through the Partnership, these issues will be addressed as the IMS continues to be developed and improved.

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Managing Contract Grading with Hypertext

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An Information Management Problem and Hypertext Solution

Trying to individualize a semester course with 40 or more students requires a cumbersome tracking system. Individualizing requires providing learning options to students with varying topics, due dates, assigned points, and project requirements. Teachers can soon lose sight of the desired results—customized educational planning—in a vast array of papers and more papers.

One solution to the problem of managing the information associated with planning individual learning is the use of a hypertext system. Hypertext products can organize and access information sequentially (like browsing through a card catalog from beginning to end) or non-sequentially (like browsing the same card catalog using topic headings). This paper describes how a hypertext solution was used in managing contract grading to increase student-centered instruction.

Contract Grading System

Before a hypertext application can be designed, the user must identify the needs and demands required of the system. The information needed must be analyzed into small discrete units which consist of a single concept or idea. The information in one node can usually be displayed on one computer screen or on a screen that scrolls up from the bottom. Hypertext allows linking of the nodes or screens into a complex interconnected system of information and references.

The information needs for the present project require creating and monitoring individual student contracts. Contracts include requirements negotiated by students in order to receive a specified letter grade and are prepared individually to allow for diversity in learning tasks. Each contract incorporates a mixture of assignments including: outside reading summaries, in-class assignments, individual reports, and a core requirement of six unit tests. Each contract component logically represents a node or screen in the design of this hypertext application.

Using HyperPAD

A relatively inexpensive DOS PC program, HyperPAD, was used for this project. HyperPAD organizes information by creating a PAD (conceptually like a note pad) of pages with varying formats. Within the contract grading system, five different types of pages were designed with distinctive backgrounds. A background defines the format or structure for entering information.

The five backgrounds designed for the contract grading system includes a(n):

- Contract Summary
- Unit Test Summary
- Report Summary

- Readings Summary
- In-Class Assignments Summary

The entire PAD consists of layered individual pages organized by backgrounds (similar to templates). Backgrounds are comprised of fields (for storing information) and buttons (for linking pages). Examining two of the background for contract grading will clarify the use of PAD, page, background, field, and button.

Contract Summary Background and Pages

Figure 1 is a replica of the Contract Summary Background which provides, by component, a summary of student progress and linkage to more detailed information. The shaded areas in Figure 1, "buttons", provide linkages to other pages when activated. The input area for "Student Name," "Contract Grade," "Point Values," and "Points Earned" are fields for storing information.

One page for each student is created using the Figure 1 background. Therefore, if 40 students are involved in contracting, the first 40 pages of the PAD would contain the individual contract summaries. Since the backgrounds define the organization of information in the PAD, all backgrounds should ideally be developed first before entering data for any individual student page.

Other Backgrounds for Contract Grading

Additional backgrounds are needed to represent the individual contract components. For example, Figure 2, the Report Summary, represents the background designed for monitoring and summarizing the assigned reports. The backgrounds for the readings, unit tests, and in-class assignments are not shown in this article, but provide the format for the information needed by each component.

The Finished PAD

Once the PAD is completed layers of pages will represent student contracts. The contract summary background, first one defined, will contain the first 40 pages in the PAD, contract summaries for each of the students. Assuming the second background defined is the report summary, the next 40 pages in the PAD will contain report summaries. Additional pages in the PAD are defined by the other three backgrounds, resulting in a total of 200 individual pages for a class of 40 students.

Accessing Information within the PAD

Information can be accessed in three ways: by sequentially paging through the PAD, by using the buttons provided on backgrounds, and by using HyperPAD's built-in query feature.

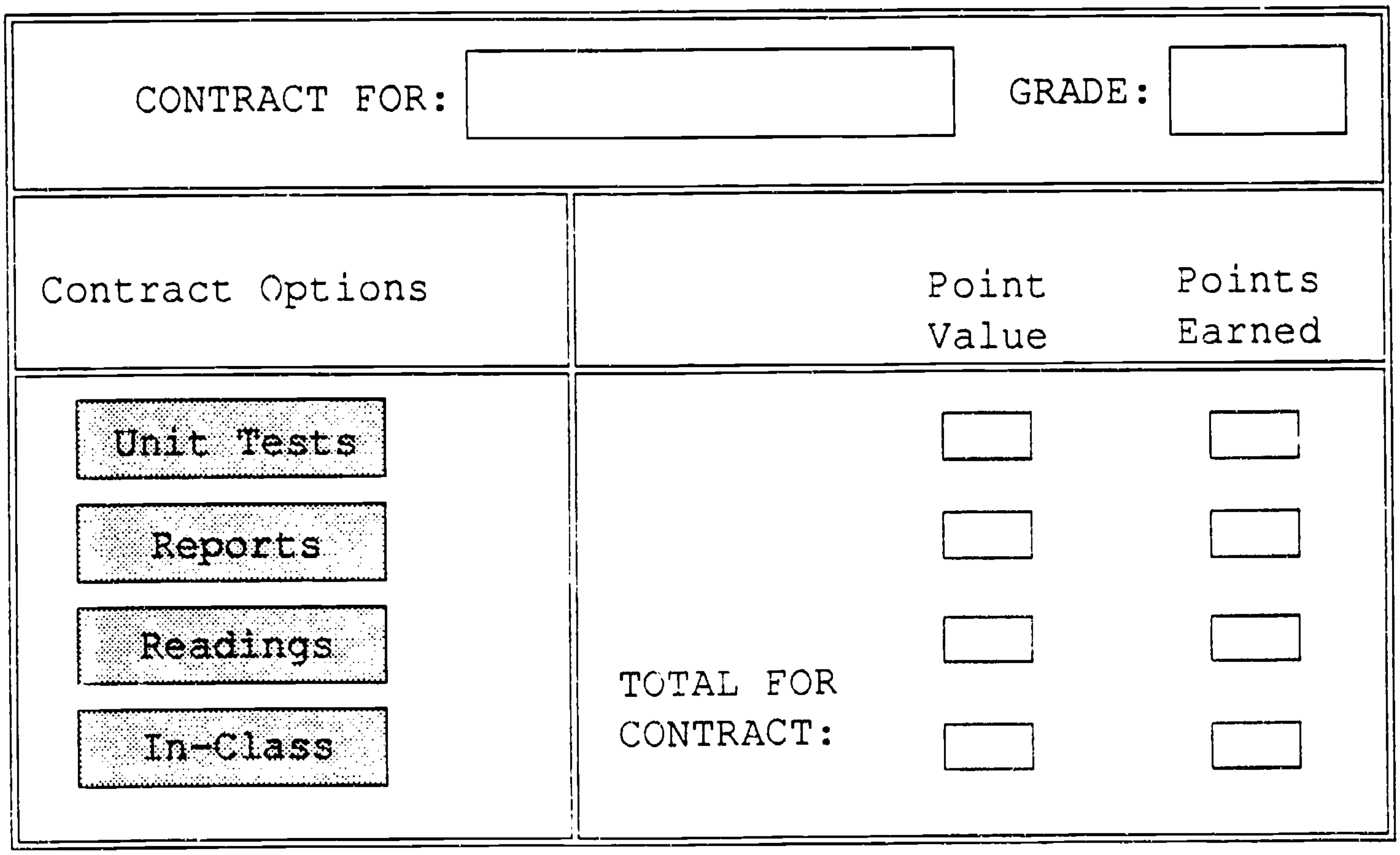

Figure 1

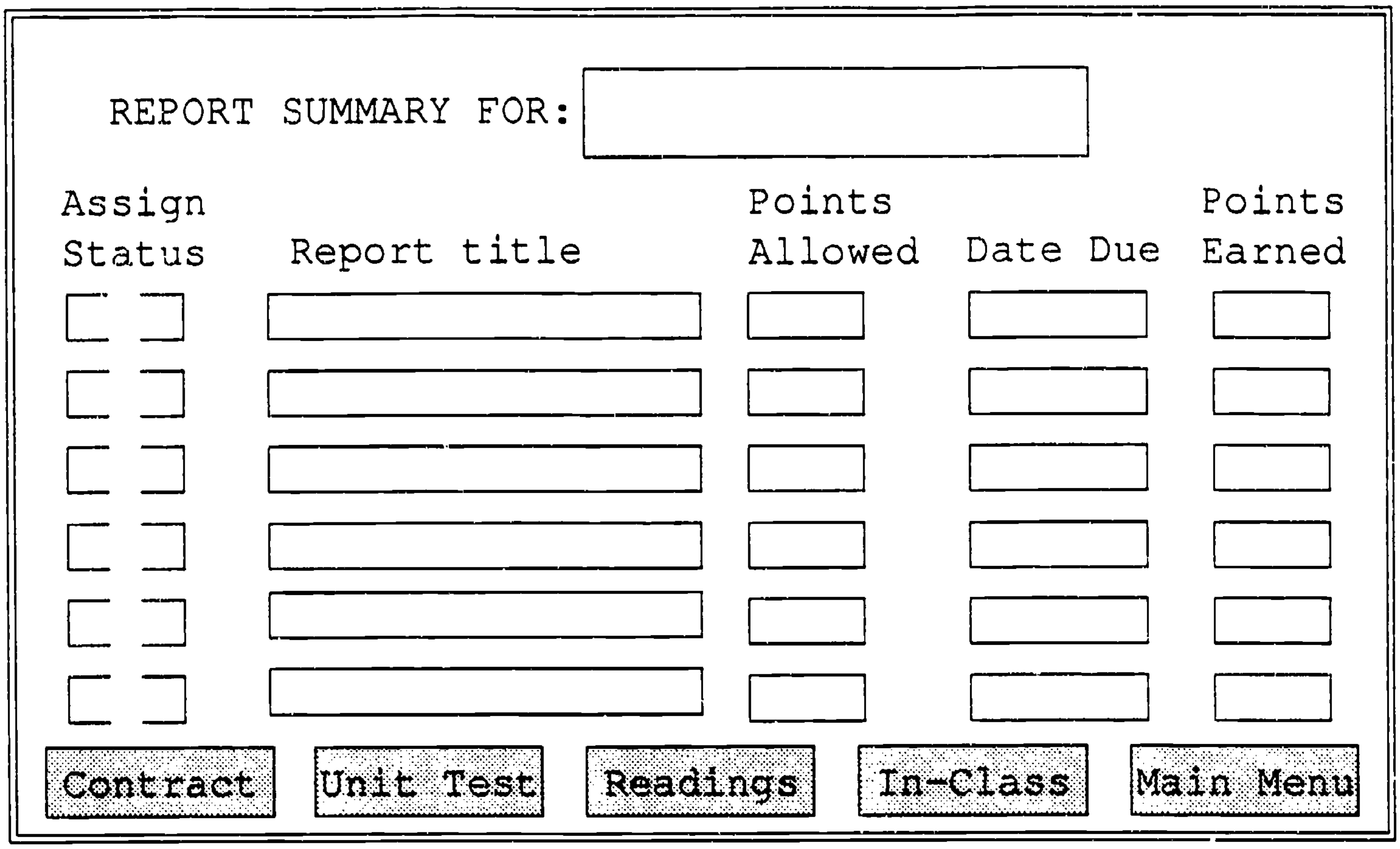

Figure 2

The buttons located on any background provide quick access to related pages in the PAD. In Figure 1, linkage is provided to unit tests, reports, readings, and in-class assignments for the same student by the buttons. For example, when John Smith's Contract Summary page appears on the screen, activating the Unit Tests button immediately retrieves and displays John Smith's Unit Test Summary.

HyperPAD's query feature allows the user to query by any background field. Using Figure 2 as an example, the field "Due Date" could be queried to retrieve all reports due during a specified time period.

HyperPAD, A Tool for Better Management

Customized educational planning is made logistically possible by an information management tool such as HyperPAD. Using technology does not reduce the creative effort needed to design workable content as well as workable mechanics. However, without the aid and help of a hypertext system the educational rewards of contract grading seem less likely for both teacher and student.

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PROJECTS

When I was asked to edit this section and write a brief introduction, I had one great fear. What if I couldn't find a common thread that tied all of the articles together? What would I do then?

Webster's Unabridged Dictionary solved my problem. "Project," according to *Webster's*, is "a scheme for which there seems to be hope of success." For the projects in this section, there seems to be great hope for teacher education and for the education of our nation's students. Each of the authors hope that as a result of the project described, teaching and learning will be enhanced. It is a section full of promise, a section full of variety, a section full of ideas.

As an educational media specialist, I've always been fascinated by unusual titles. One that comes to mind when I think about this section, although the content is pretty far removed from the projects at hand, is a Libraries Unlimited title called *Grand Schemes and Nitty-Gritty Details*. Both are present in these papers. The authors share with us their "grand schemes" for successful integration of technology into teacher education and provide us with some of the "nitty-gritty" details about how their goals have been or will be accomplished.

One of the grander plans is delineated in Ken Brumbaugh, Jim Poirot, and Curtis Beckman's article, "Applying Research to Educational Technology: The Texas Center for Educational Technology." In the article, the authors outline their plans for a statewide center which will provide products and services for Texas educators through eleven laboratories. The TCET plan relies on collaborations between higher education, business and industry, and the public schools. The plan is both comprehensive and well-developed and, if successful, should provide a model for other states and regions throughout the country. While some states have established similar centers, the formalization of the collaborative efforts described here make it distinctive. The progress made in this first year of operation toward their stated objectives is impressive.

Genevieve Davis from Kent State brings the details of another grand plan for a collaboration between industry, higher education, and two local school districts. As outlined in her article, "Computers in the Elementary Classroom," students use technology as the tool it was intended to be. Teacher education interns observe classroom teachers modeling the use of technology with their students, and education methods courses help teacher education students incorporate technology into their teaching. While the article focuses on improvements in the elementary math education curriculum, there is hope for all content areas and for all grade levels reflected in this project.

Nancy Hunt describes a project at Cal State, Fresno, to train teachers to use technology effectively at the

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preservice level. It is a hope to which each of us reading this book aspires. In "Preparing Computer Using Teachers: One State's Mandate and Models of Implementation," Nancy offers the nitty-gritty details about their technology curriculum.

In "Disseminating Technological Innovations: Strategic Alternatives," Deborah Bauder, Mary Planow, and Ronald Sarner briefly discuss their project at SUNY at Utica/Rome called CHOICES. Their hope in this project was that through the building of a support network for teachers in the educational community, diffusion and adoption of educational innovations would be facilitated. The authors discuss their successes and their "shortfalls," with an emphasis on positive recommendations for improvement.

Interactive videodisc technology, certainly a promising technology, is the innovation discussed in the next article. Nancy Hunt's "Teaching with Interactive Technologies" presents a rationale for using interactive multimedia and then describes two separate pilot projects designed to introduce teachers to IVD.

Finally, Annette Schonborn and I describe "Integrating Technology into Teacher Education: The Role of a Technology Instructor in a College of Education." The University of Central Florida has invested in a full-time faculty member to assist teacher education faculty in learning about technology and in learning to incorporate technology into the teacher education curriculum. The hopes for improved teaching and learning are described from two perspectives in this article, that of the technology instructor and that of a teacher education faculty member.

We each undertake many projects in our professional careers. With each new beginning, with each new project, there is always hope. It is such hope that ties these articles together. It is hope that brings us to this book and to this conference. My hope for you is that all of *your* hopes for improving teacher education, all of your hopes for enhancing the teaching and learning process, that *all of your projects* are successful.

Applying Research to Educational Technology: The Texas Center for Educational Technology (TCET)

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The Texas Center for Educational Technology (TCET) was created in June, 1990, with grants from the Texas Education Agency and the State Board of Education, as a collaboration between UNT and the University of Texas (UT) at Austin. Eight research and development laboratories at UNT and three at UT-Austin will focus primarily on two areas: 1) how technology can assist students in learning, and 2) how technology can assist teachers in improving instruction.

What Goals Does the Center Hope to Accomplish?

The grant calls for five major achievements to be accomplished by 1995.

1) To create a statewide exchange program (Texas Transfer of Technology) for scholars, teachers, researchers, and industry personnel. At least 25 people a year will be paid their normal salaries to temporarily change careers. The purpose is to improve TCET products and services to be delivered to schools for teaching/learning about and with technology.

2) To expand summer inservice programs for K-12 teachers. These Technology Institutes will provide technology-based teacher training for teachers and regional trainers.

3) To create several model classrooms that will demonstrate the latest in technology-based teaching and learning. Each classroom will be established for a different subject and/or level and will provide training for teachers in the use of advanced technology.

4) To share ownership of copyright and/or patents with participating TCET industry members on several new educational products and services.

5) To house a strong educational computing and technology-based research effort, making Texas a leader in educational technology.

How Does TCET Plan to Accomplish These Goals?

Eleven research and development laboratories have been established the first year to carry out the goals of the Center and conduct its daily activities. While covering broad educational research needs, they emphasize two main areas of technological research: a) how best to implement existing educational technology, and b) how to design and implement new technologies, or those not yet fully utilized in education.

The titles and brief descriptions of the laboratories follow.

Assessment of Student Learning and Cognition (UNT)

- study human learning and learning activities
- investigate and assess students' cognitive processing
- develop computer-based methods for diagnosing students' learning and cognitive processes

Student Learning and Special Populations (UNT)

- provide technological support for the learning or physically disabled, mentally retarded, and emotionally disturbed
- explore enhanced interactive media as an aid to elaborative processing
- research using expert systems to assess and diagnose learning characteristics

Teacher Productivity and Training (UNT)

- develop procedures for measuring and evaluating teacher productivity
- identify technologies that will most improve teacher productivity
- design and equip the most technologically productive model classroom

Teacher Retention and Support Networks (UT)

- provide teachers and administrators with access to technology, information, and experts to improve their effectiveness
- develop special technology-using interest groups for teachers and school administrators
- facilitate communication among master teachers

Curriculum and Instruction (UNT)

- develop technological instruction models
- determine which curriculum areas can be most positively altered by applying technology
- apply technological advances in all curricula

Multimedia and Emerging Delivery Systems (UT)

- develop model interactive multimedia programs in various subject matter areas at varying grade levels
- determine the effect of interactive multimedia on increasing learning
- identify existing technologies not used in education which have potential application to K-12 education
- create prototypes to demonstrate educational use of these technologies

Instructional Design and Evaluation (UNT)

- determine what prevents schools from using technologies proven to be effective instructional tools and methods
- provide teachers with design and evaluation tools that will help them select and use appropriate technology
- inform school administrators of the factors that prevent adoption of successful technology, and suggest ways to overcome these obstacles

Educational Telecommunications and Informatics (UNT)

- conduct pilot projects to demonstrate effective telecommunications and informatics technologies
- conduct training institutes for teachers and administrators
- evaluate and demonstrate current and future technology for teachers, administrators, and researchers

Design of Computer-Based Instruction (UT)

- teach instructional designers and teachers ways to account for the diversity of learners when designing and implementing computer-based instruction
- develop prototypes of computer-based concept lessons using hypertext
- investigate how learner characteristics affect performance and attitudes in computer-based, hypertext instruction

Brain Mapping and Evoked Potential (UNT)

- explore the use of computerized administration and/or scoring of psychological, aptitude, and achievement tests
- place neurocognitive tasks into a hypertext environment
- evaluate the brain's electrical activity while subjects are performing neurocognitive tasks

Collaborative Software Development (UT)

- use graduate student/classroom teacher pairs to produce instructional computing applications and utilities
- develop hypertext stacks for areas defined by inservice teachers

What Other Activities Will TCET be Involved In?

In addition to the eleven research labs, a variety of collaboration and dissemination activities will also occur. A brief description of those currently planned follows.

Educator/Corporate Interchange

Businesses who have educators as clients may not have access to adequate end-user evaluation before marketing their products. The TCET Interchange will arrange for teachers and students to provide product-use feedback for corporate members.

Technology Excellence (TEX) Contest

This annual contest seeks to identify the best technology-using teachers in Texas. The winners are awarded cash prizes, with a top prize of $2500.

Best Technology in Texas Tapes

After each TEX contest, a video tape will be prepared to present the top-rated submissions. It will introduce the teacher, the technology, and explain and demonstrate why it works well in the classroom.

Electronic Mail Service

TCET is establishing a system (CET-Net) to allow communication with educators throughout Texas. Daily mail checks will result in quick response to questions or requests for assistance. The questions will be kept in a database and answers to the most frequent ones will be printed and distributed.

Texas Technology Tour

TCET will work with its business and industry affiliates to conduct a series of visits to the Regional Service Centers throughout Texas. TCET staff will provide training sessions for Regional Center staff at least once a year.

Summer Teacher Institutes

Graduate credit mini-courses will be offered to technology teachers on topics related to TCET research. Competitive stipends will be awarded to selected Texas teachers to attend. Some of the classes and/or demonstrations will be videotaped and made available for a nominal fee.

Student/Faculty Lecture Series

Regular presentations will be made on state-of-the art technology and applications of research projects. These open-exchange sessions will be available to all interested students, faculty, and local business and industry personnel. Videotapes of the presentation may also be made available.

Videoconferencing

Periodic video conferences will be produced by TCET and its members, allowing for simultaneous state-wide participation in the presentation and discussion of issues relevant to educational technology.

Instructional Television

TCET plans to work with the local PBS affiliate to produce and air programs exploring the effective use of educational technologies.

TCET will be publishing and making regular conference presentations at NECC and other conferences, including the Texas Computer Education Association and the Texas Association for Educational Technology meetings. The Center will also print and distribute brochures, research reports, and a quarterly newsletter.

Who Will TCET Be Working With and Serving?

The Center encourages any individuals and groups who are interested in the use of technology in education to become a member of TCET. Membership may include all educators and educational institutions who are associated with public schools, community colleges, service centers, private colleges, and public universities, as well as various educational technology companies in business and industry, and related organizations and agencies.

Educational memberships are offered to any interested public school districts, as well as to post-secondary institutions. Educational members may take advantage of workshops and symposia for teachers and administrators, have access to Center consultants to work at the district site, and participate in other Center activities.

Corporate membership in TCET is actively solicited as well, with emphasis on the tangible benefits available to corporate members. These benefits include participation in workshops and symposia, consultations by TCET staff, faculty, and student interns, and dissemination of research findings. These businesses will also have the opportunity to market some of the products developed by the TCET research laboratories.

What Has TCET Accomplished So Far?

The following information presents some of the results obtained, activities accomplished, and commitments made by the 11 research and development laboratories, along with activities that have taken place in the TCET administrative office through February, 1991.

Annotated Bibliographies/Research Reports

The Instructional Design and Evaluation Lab has finished work in two areas: "Graphical User Interfaces (Icons) in Instructional Modules" and "The Diffusion and Adoption of Technology in K-12." The Design of Computer-Based Instruction Lab has draft versions of "Cooperative Learning and Computer-Based Instruction," "Using Technology in Multicultural Classroom Environments," and "Individual Differences of Learning Styles." The Multimedia and Emerging Technology Lab also has a draft version of "Digital Audio Sampling and Compressed Speech."

The Educational Telecommunications and Informatics

Laboratory has published a research report entitled "Augmenting Satellite-Based Distance Education Through Video Capture Technology" which describes capturing the transmission to video tape and printing out the video images for student use. The results suggest that using proper graphics equipment would allow distance education students to receive supplemental materials in class with little time delay.

Collaboration With Schools

The Lamplighter School is a prestigious private school in Dallas which contracted with TCET to conduct a study of the school's current and future technological needs. After discussions, exchange of materials, and a site visit, TCET prepared an evaluative report which was submitted to the school's Board of Trustees for their consideration and possible action.

The Fort Bend ISD is a large, growing suburban district near Houston which asked TCET to review and help revise their long-range Instructional Technology Plan. All districts must file a 5-year technology plan with the Texas Education Agency, but Fort Bend wanted to surpass that basic requirement to create a "model plan" that other districts in the state could emulate. The contract covers several months, involves multiple site visits, and will culminate in an extensive written report. After receiving TCET's evaluation and recommendations, the Fort Bend Long-Range Technology Planning Committee will submit their final product for School Board approval.

Contracts With Businesses

TCET is conducting a study of "Level 3" educational videodisc usage in K-12 for Pioneer Communications to identify and evaluate appropriate uses of interactive videodisc software/courseware and hardware. Study results will be presented in two publications. One will be a brief "Planning Guide" for educators and a set of three 10-15 page "User's Guides" covering level of instruction, mode of instruction, and discipline/subject area for appropriate "level 3" instructional uses of laserdisc technology.

TCET also has contract with Wicat Systems to conduct three research studies. The first will develop an Assessment Kit for schools to help determine the scope and requirements of an integrated learning system to meet their educational goals within budgetary constraints. The second will provide a research report to determine teacher concerns with and stages of use of integrated learning systems. The third will identify emerging technologies which could be combined with integrated learning systems to increase student and teacher use of the systems.

Conclusion: TCET's Vision for the 90's

The current state of technology in education holds great promise for the future. However, much of the present research work, pilot projects, and applications are being pursued in isolated pockets nationwide, resulting in limited adoption and/or acceptance in public schools. TCET intends to become the means whereby these diverse projects and technologies can be pulled together in a coordinated and synergistic manner to accelerate their diffusion into Texas education. To that end, TCET will pursue three continuing objectives:

1) to integrate existing technology into education more effectively,
2) to repackage existing technology into more efficient and cost-effective configurations, and
3) to conduct original research into better uses of emerging technologies for instruction, administration, assessment, and measurement.

TCET plans to serve as the catalyst for accelerating the effective use of technology into education. The Center will seek to work closely with all educational technology activities across the state, whether funded by major technology corporations, governmental agencies, or school districts. TCET's coordinating role can create a synergism among similar and supporting efforts.

The Center seeks to become the transfer conduit that can give focus to a variety of efforts and help move technology into other development projects. The Texas Center for Educational Technology will conduct research and development activities that can fill gaps not covered by existing activities. The result will be a more cost-effective, mutually reinforcing network of educational technology efforts. Becoming the technology transfer conduit in Texas will allow the Center to foster a more immediate diffusion of technology into the classroom while attracting educational, organizational, and business funding to sustain its future operations.

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Computers in the Elementary Classroom: A University, School, and Business Collaboration

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Children in today's schools will be adults living and working in the twenty-first century. It is imperative that today's schools prepare children for tomorrow's world. Advancements in technology have changed employment trends, communication systems, career opportunities and everyday living. As the demands of society change so do the demands of our schools. Children need to enter the twenty-first century with the knowledge base and skills necessary to be productive and successful.

Over the past decade numerous reports have been published implicating the shortcomings of American education (Dossey, Mullis, Linquist, & Chambers, 1988; McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers, & Cooney, 1987; National Commission on Excellence in Education, 1983; National Research Council, 1989). Documented in these reports and analyses are the deficiencies in the mathematical performance of United States students. In response to the challenges inherent in these reports, the National Council of Teachers of Mathematics (NCTM) has produced its "Curriculum and Evaluation Standards for School Mathematics" (1989). This document outlines the broad mathematics curricular goals to be implemented in today's schools for tomorrow's world. The "Standards" call for a change in the way mathematics is taught and learned. Children are to be actively engaged in the construction of knowledge, and in dialogue about their investigations, discoveries and inventions. This construction must involve children working with manipulatives supported by technology.

The educational agenda of our nation has been made clear. The targeted areas are clearly mathematics, science and technology. In order to implement the recommendations made by the "Standards" (NCTM, 1989) in an appropriate fashion, additional teacher preparatic will be necessary for both preservice and inservice teachers. Moreover, as we prepare students to function in tomorrow's workforce, it becomes necessary to involve industry in collaborative efforts in preparing teachers. Hence, the genesis of the Lighthouse Education Enhancement Project (LEEP).

Rationale and Motivation for Project LEEP

The Lighthouse Education Enhancement Project was submitted to the IBM Program for Teacher Preparation Enhancement in the Use of Available Technology. The grant requested that IBM join in a partnership with Kent State University and two local school districts. The partnership's purpose was to demonstrate that teacher educators working together with public school administrators, teachers and IBM personnel could implement the vision of incorporating computers into daily classroom practice. It was proposed that the initial efforts of this project be focused on the mathematics curriculum for Kindergarten through grade six. The long range goals included expanding computer enhanced instruction to science and ultimately to all curriculum areas. In this proposed partnership, Kent State University was to provide faculty expertise in the area of computer enhanced mathematics instruction and to prepare cohorts of teacher education students to complete planned teacher education field experiences and student teaching in the collaborating school sites.

The school sites would provide working models of computer enhanced instruction in the area of mathematics and field supervision of teacher education students completing planned field experiences and student teaching. IBM would provide technology (hardware and software) and training for both teacher education programs and related school based programs. IBM, Kent State University, and the collaborating school districts would work together to provide inservice for both school and university based participants to support the effort.

Goals of Project LEEP

A major goal of Project LEEP is to demonstrate how a technology enhanced mathematics teacher education curriculum could be articulated with elementary school classroom practice. A second goal is to demonstrate how partnerships among teacher education faculty, public school personnel and private sector personnel could improve the technological literacy and instructional performance of both preservice and inservice teachers. A third goal is to demonstrate that a technology enhanced mathematics curriculum could significantly improve student performance on appropriate measures of mathematical achievement. The last major goal is to demonstrate a support system that enables teachers to incorporate technology into the elementary school mathematics curriculum as described by NCTM in their 1989 "Standards".

The Lighthouse Education Enhancement Project clearly defines a vision of classroom environments (on campus and out in the field) compatible with a constructivist view of teaching and learning enhanced by technology. The proposed classrooms and resources available at Kent State and at IBM would ultimately provide for ready and frequent access by all students and teachers to networked computers, video disks, CD ROMs and on-line retrieval services. Technology would be viewed as a tool that would assist children in their thinking, problem solving and creative efforts. Kent State University students could observe and model teachers who are incorporating computers into their classroom environments. There would ultimately be a good fit between university methods courses and public school practice.

Teacher Education Component

The goals and objectives of the grant are consistent with NCTM guidelines. The staff development component is designed to be on-going in nature. As the teachers are inserviced by Kent State University and IBM personnel, they are assured of on-going support.

In analyzing the Project LEEP journal entries by the participating teachers, it was clear that attitudes and practices relating to math instruction had changed for the better. There was considerable evidence of frustration, however, with the software and hardware training. The technology component was not received as smoothly as the mathematics education component. The teachers generally agreed that the technology training they received by the IBM staff was, in the words of many, not beneficial. The teachers voiced many concerns. They suggested that for the next year's cohort group, technology training should provide for adequate practice time. They were in agreement that more time was needed to explore introduced software. In this vein, they suggested that the IBM staff cover fewer topics in greater depth. Also, they wished to have more "helpers" available during training sessions. A possible format suggested was a "buddy system".

The teachers were opposed to the three consecutive concentrated day long sessions and suggested many half day sessions over a longer period of time. Many also suggested that the delivery of computers ought to coincide with the inservice so that they could engage in some semi-private practice time. Some even voiced the desire to take the computers home to practice on them before they were installed in their classrooms.

These suggestions have been carefully considered as the second group of teachers begin their technology training component of Project LEEP implementation.

In an attempt to provide the first group of teachers with a re-training on the computers, three days were set up for individual exploration on the network with ample assistance. It should be noted that a group of teachers have felt confident and comfortable with the computers and have been offered additional training with multimedia. Some teachers have even inquired about keeping their journal entries on diskette.

The IBM Role

IBM offered a staff development component which provided three week long training sessions on site in Atlanta, Georgia. These sessions were designed to provide support for faculty members participating in the "IBM Program for Teacher Preparation Enhancement in the Use of Available Technology," and one Kent State faculty member attended each session. The first session was designed for a faculty member oriented to be the network systems operator. The second session was designed for a faculty member who teaches preservice courses at the early childhood and elementary school levels. A third session was offered for a secondary education faculty member.

The intense week long training was very intensive. IBM speakers and technicians were on hand to present their hardware and their full line of courseware. It was impossible to explore the applications software, the content area courseware and the multimedia software in any depth. It was generally agreed upon by the faculty members in attendance at these training sessions that more "hands-on" time was desired. It is interesting to note that such responses were in concert with the responses generated by the public school teacher participants with respect to the technology training.

Hardware and Software Installation

Coordinating the installation of the networked computers in the public school classrooms, the University lab and the University mathematics and science education classrooms was a difficult task. Technological issues relative to cabling were responsible for holding up ready implementation at all sites. However, such "hold-ups" provided more time for the teachers to develop a readiness for using the technology.

The installation of the networked IBM Computer Lab at the University was completed months before the University mathematics and science education classrooms received their targeted networked computers. This delay did not cause the project to be halted. In fact, the semester the computers were installed in the University methods classrooms, was the first semester the public school teachers were ready to accept field experience students in their classrooms to teach mathematics enhanced by computers.

Discussion

In general there has been overwhelming cooperation and enthusiasm for Project LEEP. As the teachers gain confidence in teaching mathematics in appropriate ways and enhanced by computers, they are eager to share their triumphs with others. The journal entries by teachers and children indicate a feeling of personal benefit from the use of manipulatives and technology in the classroom. It is clear that the project is off to a productive start. As the teachers continue their on-going inservice and as cohorts of teacher education students are prepared at Kent State to teach in the Project LEEP sites, more data will be collected.

As the project continues many research questions will be explored: What is the nature of changes in participants' (preservice and inservice teachers) knowledge, skills, and attitudes in the teaching of mathematics and technology's role in that process? What is the nature of mathematical improvements for the children? What is the nature of mathematics curricular changes in the participating school systems? What is the impact on university preservice students of a coordination of classroom methods courses and school field sites in methodological approaches to teaching mathematics? And, what impact will computers have on the teaching of mathematics if computers are used as an instructional tool in the classroom on a consistent regular basis?

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Preparing Computer-Using Teachers: One State's Mandate and Models of Implementation

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California is one of a growing number of states that have recognized the importance of teacher training in the use of educational technology. Effective July, 1988, all California Teacher Credential (CTC) Commission-approved institutions must provide evidence that their program requires Clear Teaching Credential candidates to:

1. Identify issues involved in the access to, use, and control of computers in our society.
2. Demonstrate knowledge and use of basic computer terminology, operations, and capabilities.
3. Demonstrate a basic understanding of selection and use of CAI, applications, and utility software appropriate for the credentialed grade level or subject area.
4. Demonstrate the application and use of a computer to enhance problem solving skills, critical thinking skills, or creative processes appropriate to the subject area and grade level.
5. Demonstrate the integration of computer applications within the credentialed grade level or subject area.

Though these competencies were very specific, institutions were free to determine how they would implement the requirement. Jonsson (1990), reports a wide variation in such descriptors as the number of units, amount of hands-on computer time, and instructor status (tenured, tenure track, part-time lecturer, etc.).

One Institution's Program

California State University, Fresno has one of the largest teacher preparation programs within the state, recommending 1200 to 1300 students for credentialing each year. Its School of Education and Human Development (SOEHD) first offered computer literacy courses in 1981. These courses, like others of the era, primarily focused on BASIC programming.

To meet the newly established CTC requirements, the SOEHD began offering TEd 134, Educational Applications of Microcomputers in 1987, a three-unit semester course catalogued as two hours lecture and two hours lab. All on-campus sections are taught in a 25 station networked Apple IIgs laboratory equipped with a ceiling-mounted video projector for RGB and composite signals. Off-campus sections are taught in junior college and high school computer labs. Classes are designated as early childhood, elementary, or secondary education sections, with the content consisting of a common core and varying emphases as recommended by Kelly, Harris, & Shelton (1990).

Initially there was a heavy reliance on computer educators from local school districts to teach the multiple sections of TEd 134. However, program growth created new tenure-track positions and most sections are now taught by tenured or tenure-track faculty. Two program changes became effective Fall, 1990. A materials fee was instituted and students were required to have some classroom experience prior to enrollment. This prerequisite eliminates the incongruity of having students with no teaching experience being expected to demonstrate proficiency in teaching with computers.

Class content remains focused upon the competencies required by CTC regulations. However, as new technologies become available, faculty are demonstrating hypertext, telecommunications, and interactive laser videodisc.

Course Evaluation

Any program charged with the preparation of teachers should evaluate program and course effectiveness. In an initial attempt to determine the impact of TEd 134 on classroom teaching, 100 TEd 134 graduates were surveyed in July, 1990. The 33 respondents indicated they use computers for writing letters to parents, creating tests, and preparing lesson plans. They reported using word processing, math, and language arts software with their students; but most did not use spreadsheets, databases, or programming languages.

The respondents stated that the availability of printers, curriculum-related software, and support personnel facilitated their educational computing program. Inhibiting factors were lack of time to learn about software, too many demands of the instructional day, and limited computer access. (Most indicated they do not have a computer in their classroom).

Further research needs to be done to determine the ideal course structure, teaching methods, and instructional strategies which promote later classroom implementation. As teachers tend to teach as they were taught, work needs to be done which will encourage the modeling of technology usage throughout the teacher preparation program.

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Disseminating Technological Innovations: Strategic Alternatives

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In efforts to determine outcomes of educational reform, change is conceptualized as an event or decision rather than as a process consisting of three overlapping phases: adoption, implementation, and institutionalization (Fullan, 1982). While this view of change is important, it must also be recognized that the process is not linear. From the outset, change in any system must involve consideration of all of the phases and must provide for feedback from [illegible]n. Equally important are the perspectives of the various constituents of the educational community involved in the change. The Concerns-Based Adoption Model (CBAM) considers these perspectives in each phase and provides a frame of reference that facilitators use for understanding the concerns of their clients (Hall & Hord, 1987).

This type of framework was considered in the design of Project CHOICE (Curricular Help On Integrating Computers in Education), funded with a grant from the U.S. Department of Education's Office for Educational Research and Improvement under the Secretary's Fund for Innovation in Education (PR/Award # R215A92073). A fundamental aspect of the design of the project is the building of a support network for teachers among peers, school administrators, teacher union presidents, and teacher center directors.

After completing one year of Project CHOICE, several tentative conclusions emerge. These are loosely grouped into two categories: successes and shortfalls.

Successes

Six successes can be identified:

1. The intensive graduate course at the beginning of the summer worked well.
2. The availability of Project CHOICE personnel to provide year-round support was appreciated by those who used it and was reassuring to all.
3. The provision of hardware and software through the project was essential and was supplemented through a loan program.
4. The follow-up sessions were highly successful in providing a channel for sharing of information.
5. Project activities, including the full-day showcase of participants' work held for administrators, teacher center directors and union presidents, forged new professional relationships. Guest speakers at the workshop report several contacts requesting more information.
6. Several school districts have announced plans to adopt project activities throughout the district.

Shortfalls

Recommendations for improvement concern the following:

1. Participation for the follow-up sessions fell off during the year, in part because grades had already been assigned, and in part because of scheduling. Delaying grades and securing needed release time should mitigate this problem.
2. Light attendance by administrators and other support personnel at the showcase of participants' work was a disappointment. Various strategies to enhance participation have been developed.
3. A lack of equipment for teachers at home compromised the ability of some participants to continue their work once the intensive training was completed. A solution appears to be for the supporting school district to provide equipment on loan.
4. Participants are more comfortable using the same configuration of equipment they will be using in their classrooms, but college facilities are not sufficiently diverse for that. Again, equipment loans from the school district would alleviate the problem.
5. Cooperative learning techniques used in the summer classes were not always successful. This area needs further investigation.
6. There was a lack of uniformity of in-service training done by the participants in their home districts. Upon reflection, however, it may not be feasible to set and enforce measurable and definable standards for in-service across districts.

In reviewing the successes and shortfalls of the project, it is apparent that there are multiple audiences, each with its own set of overlapping but not necessarily congruent concerns. As Project CHOICE continues, strategies to address these various sets of concern are being developed and tested.

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Teaching with Interactive Technologies

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Americans live in a media-rich environment, surrounded by television, radios, movies, and digital sound. We rely upon electronic media to keep us informed. Satellite communication allows us to see and hear events as they happen around the world.

Too often children are expected to depend entirely upon printed text and visuals to get their information. If we are to make school an exciting and relevant place to be, we must reach our students through, and empower our students to use, the technological tools of the age. Unfortunately, the typical classroom is less well equipped than the average American den.

How can we use modern technology to educate our children?

By the mid-1980's most educators were familiar with computer assisted instruction (CAI). When computers were first introduced to the schools they were used for either the teaching of programming or for basic skills instruction. Educators have come to understand that most of our students will not become computer programmers, and the jury is still out on the transfer of programming skills to other broader problem solving situations.

Certainly the computer serves as an efficient and patient tutor, presenting example after example and offering immediate feedback regarding the correctness or incorrectness of the student's response. Many computer labs were installed for the express purpose of developing underachieving students' basic skills. Often expensive Integrated Learning Systems, software-based curriculum materials with a management feature which tracks student performance and placement within the package, were purchased to run in the labs.

Some computer educators, however, question the value of installing expensive computer laboratories which focus on basic skills instruction through a drill and practice format. Stanley Pogrow (1990) suggests that weak students do not underachieve due to lack of practice, their primary problem is that they are rarely given opportunities to think abstractly. They do not know how to link ideas into elaborate conceptual webs, they can't generalize, hypothesize, or predict events. Too often low achieving students are continually drilled on low-level cognitive tasks and not given opportunities to practice solving problems with higher-level cognitive demands.

Using CAI solely for basic skills practice is an almost criminal underuse of the technology's power. Through the use of simulation and problem-solving software, computers have a tremendous potential for assisting students to develop their higher-order thinking and inquiry skills. Simulation programs like MECC's "The Market Place" and "The Oregon Trail" require students to manipulate a number of variables and continually make decisions based upon the consequences of their previous actions. Problem-solving software presents a puzzle or problem which the students must solve using any of a number of problem-solving strategies. For example, Sunburst's "The Incredible Laboratory" requires students to recreate monsters by forming and testing hypotheses. The Learning Company's "Rocky's Boots" requires students to use Boolean logic operators to build electric circuits which will separate objects.

Current trends indicate that educators are moving toward broader, more sophisticated uses of technology. Students are using computers as productivity tools. Word processing greatly facilitates the teaching of writing as an evolving process. Databases allow students to organize quantities of data into usable information that facilitates the discovery of relationships among the data, and allows students to gain a deeper understanding. Modems and telecommunications software allow students to access the world. They can exchange information about their daily lives with students across the globe or, through the use of curriculum projects such as National Geographic's "KidsNet," become scientists and participate in real research projects.

Another important trend is the interfacing of the computer with other media (Colvin, 1989). This integration of computers, videotape, CD-ROM, and laserdisc technologies gives teachers and students a tremendously empowering opportunity to express themselves and direct their learning. Fred D'Ignazio, a leader in the educational use of these media, has termed this powerful combination a "multimedia pencil."

What is meant by "multimedia," "hypertext," and "hypermedia?"

In the past, a presentation which used synchronized multiple media such as an audiocassette tape player and filmstrip projector were referred to as "multimedia." Today's definition of multimedia is much broader, referring to the use of a computer to orchestrate an integration of text, graphics, audio, still images, and motion picture sequences. The computer controls equipment such as computer screens, video monitors, VCR's, CD-ROM discs, laser videodisc players, and video and audio-digitizers.

"Hypertext" refers to written text which can be reviewed in any sequence of the reader's choosing. The author enables the reader to do this by linking passages of text (and often graphics) with "hot spots" or "buttons." For example, the author might write a passage about the life of Napoleon. At key points the author may highlight a word or include an icon which signals the reader more information is available. The reader might have the option to see a picture of Napoleon, review a map of Napoleon's campaigns, skip to a passage about his exile on Elba, get biographical data on Josephine, or obtain a definition of an unfamiliar word. In other words, each time the material is read it could be accessed in any sequence and to any degree of detail.

"Hypermedia" borrows from both multimedia and hypertext. The key element in hypermedia is its interactivity. Learners do not have to sit passively watching a presentation someone else has prepared. They are allowed to interact with the media themselves. They can access the presentation in any order of their choosing and they can use the many resources to create their own study materials, thus guiding their own learning.

Bill Atkinson, the creator of Hypercard, the first widely available hypermedia authoring tool, refers to it as an "electronic erector set" which creates new possibilities for teaching and learning. Users can organize and present information by linking it to text, graphics, digitized sound and images, or media such as laserdisc players and CD-ROM drives.

What are the characteristics of hypermedia which offer promise for education?

Gary Marchionini (cited in Azarmsa, 1991) has identified three characteristics of hypersystems which have great educational potential. First, as stated above, hypermedia offers the learner a new way to learn. It allows the integration of diverse materials and gives learners the option of following a well-marked linear path or blazing their own trails through the content. Marchionini refers to this as a "fluid environment [which] requires learners to constantly make decisions and evaluate progress, thus forcing students to apply higher order thinking skills" (p. 170).

Second, hypermedia systems allow easy access to huge collections of information in a variety of media. For example, one video laserdisc can store 54,000 video frames. This number can be envisioned by stacking enough carousel slide trays to equal the height of a seventeen story building!

Similarly, one CD-ROM disc can hold the equivalent of up to 300,000 pages of text. One currently popular and widely used CD-ROM disc contains the 26 volumes of Compton's Encyclopedia, the complete Webster's Intermediate Dictionary, and thousands of additional color images, audio sequences, and moving animations. The disc facilitates student research by accepting key word searches and providing a built-in "Writing Processor" which allows students to take notes and copy blocks of text.

Finally, hypermedia offers a tremendous potential for enhancing teacher-student and student-student relationships. Teachers and students can learn from each other. Its flexibility makes possible the creation of lesson components which can be accessed at random and used in still other lessons. Students may develop their own tours through the knowledge base and share their experiences with their teachers and other learners. Further, the creation of multimedia and hypermedia materials fosters cooperative relationships among students as they work together to share the creativity and responsibility needed to produce such a project.

How is hypermedia being used in schools?

This author has recently been involved in two hypermedia projects, one working with middle school students and the second with a group of elementary school teachers.

Tioga Middle School

The impetus for the middle school project was a local conference which focused on effective strategies for teaching students at risk of dropping out of school. The call for presentations package included a sample list of topics suitable for inclusion in the program. Technology was not even mentioned!

The author immediately contacted Mr. Dennis Funk, the computer coordinator for the school district sponsoring the event, regarding this gross oversight. He readily agreed to develop with the author a presentation which would delineate how technology could be used to reach and serve at-risk youth.

The collaborators decided to work with two students representative of the at-risk population. The goal was to determine if, with minimal assistance from adults, these students could produce an interactive, multimedia (hypermedia) presentation. Another goal was to assess how this experience might impact their attitudes toward and behavior in school.

The principal and special resources teacher at a middle school near the university campus agreed to identify two students who could be described as "at risk" and, upon receiving parental permission, let them participate in the activity. Two eighth grade Hispanic boys were chosen for the project. Their science teacher agreed to allow the boys to present their work to the class and give them extra credit for their efforts.

The students were shown a laserdisc player and given operating instructions. The boys chose a topic, volcanoes, after reviewing a collection of videodiscs. They generated a list of questions about volcanoes, divided the list between themselves for research, and used library resource materials to find the answers to their questions. They were also instructed to look through the videodisc resources to identify frames and motion sequences which answered their questions.

Then a Macintosh computer was brought in, and the students were introduced to Hypercard. They learned how to create graphics, text fields, and buttons which linked screens of information (referred to as "cards") and controlled the videodisc player. During the last week of the project they used MacRecorder, a sound-digitizing system, to record their voices into the presentation.

The students met with the author or her collaborator for one and a half hour intervals once or twice a week. They had additional access to the equipment after school and during free periods of the school day.

The conference presentation was a major success. The packed audience politely tolerated the collaborators' introduction, but were truly amazed at the quality of the students' work. Participants asked many questions, some about the use of the technology itself, but mostly about how the project was created, how the students felt while working on the project, what they learned from it, and how the project related to their other school work.

The boys admitted that at first they were a little scared they wouldn't be able to do this but it turned out to be "easy." They said they learned a lot from the project, and that working with the computer and other equipment made learning fun. They also indicated that they were usually pretty messy, but learning how to organize the materials they wanted to present helped them see how they could be better organized for their other classwork.

Mountain View Elementary School

The second project, working with elementary school teachers, began in the fall of 1990. The IBM Corporation awarded a $150,000 equipment grant to support a joint development project proposed by the author and Mr. Charles Philips, computer coordinator for the Clovis (California) Unified School District. It was proposed that the equipment be used to develop teacher inservice materials and lessons integrating the use of interactive laserdiscs and IBM's hypermedia program, Linkway, to teach California's History/Social Science Curriculum Framework.

The rationale for the proposed project was that the main focus of the California History-Social Science Curriculum Framework is the study of "continuity and change." The use of computers, laser discs, VCR's, and other technologies, enables teachers to better present the history/social science curriculum as an..."exciting and dramatic series of events" by developing their own visual documentaries. Students' use of the same technologies, simulation software, word processors, and visual documentary approach enables them to "increase their critical thinking skills while... (being) actively engaged in the learning process."

The IBM equipment was to be delivered in March, 1991. The collaborators worked with the teachers for two hours per week approximately one month prior to the delivery of the equipment. Although it was an option, all seven participants chose to receive university credit for their participation.

At the time of this writing, the teachers have seen sample interactive laserdisc materials, reviewed laserdisc resources and the state and local history/social studies curriculum guides for their grade level, learned how to manually operate the laserdisc players, and paired in grade-level teams to select the topic and content-area objectives with which they wish to work. Once the computer equipment is delivered, the teachers will be taught how to use Linkway to create interactive programs which incorporate the use of text, graphics, digitized video images, and laser videodisc resources.

The teachers will then plan and teach a lesson based upon their newly created hypermedia presentation. They will regroup, debrief their experience, and revise their lesson plans to enhance the positive attributes and strengthen any weak areas. Finally, the teachers will develop curriculum and inservice materials which will be used to assist students and other teachers use hypermedia in their classrooms.

The project will result in curriculum packets and inservice materials which will be disseminated. Additionally, pretreatment and posttreatment surveys will be analyzed to determine any attitudinal differences and evidence of changes in technology usage throughout the school.

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Integrating Technology into Teacher Education: The Role of a Technology Instructor in a College of Education

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Like the faculty in many colleges of education, College of Education faculty at the University of Central Florida are keenly aware of the impact of new and emerging technologies for instruction and for information management. Faculty seeking to integrate technology into the teacher education curriculum encountered many barriers. The physical arrangement of college classrooms is frequently not conducive to the utilization of technology. A lack of resources limits the amount of equipment and software which are available. Students at the college level frequently are not accustomed to learning through technology, and few resources have been identified which specifically address the content of the teacher education curriculum.

Most UCF College of Education faculty feel strongly that they should model the use of technology in instruction, not merely talk about it. Many faculty, however, are more comfortable teaching in a traditional manner. Anxiety and lack of knowledge about the equipment, software, and changes in teaching style were identified as the primary barriers to successful modeling. Faculty felt they had a limited amount of time to invest in learning about new technologies, examining software packages, or mastering authoring systems. Many felt this time would be better spent in research and writing, where rewards for time invested are more tangible. Most importantly, faculty felt they would be "on their own" in learning to use technology. No support staff was available in the College for faculty who tried to learn about technology, and the need for a skilled staff member became apparent.

In the summer of 1990, the College of Education funded a full-time faculty line designated as "Technology Instructor" to assist the faculty and staff in implementing technology and the effective use of computers into their work environment. The line was assigned to the Dean's office rather than to one of the four departments, and no teaching duties were assigned. Instead, the Technology Instructor was assigned to assist faculty and staff and facilitate the use of technology in the college. The remainder of this paper will focus on the role of the Technology Instructor from two different perspectives: that of the College faculty, and that of the Technology Instructor.

The COE Faculty Perspective

Background

Florida has been investing in technology for many years. The Florida High Technology Council was established to help attract high-tech businesses to Florida. The University of Central Florida is located in the midst of a high-tech corridor in Orlando. UCF is surrounded by such high-tech entities as Westinghouse, Martin Marietta Aerospace, NASA, and the Central Florida Research Park. The Research Park is the home of several technology related businesses as well as the Naval Training Systems Center which houses training and development divisions for the U.S. Navy and the Marine Corps. UCF has outstanding programs in engineering and computer science, and it is home to the Institute for Simulation and Training and CREOL, the Center for Research in Electro-Optics and Lasers. The campus has an outstanding reputation for advanced computer capabilities. It has long been a test site for Novell products and has installed some of the first fiber optic networks. It was the first institution in the nation to use blown fiber technology.

UCF is located in Orange County, one of the largest school districts in the nation, and the College of Education provides on-site services for approximately twenty surrounding school districts through Teacher Education Centers. Florida schools have benefited from the technological orientation of its Commissioner of Education and the Department of Education's Office of Educational Technology. It is one of two states in the nation to have established a Model Technology School program, and it annually holds the nation's largest state technology conference for educators.

The College of Education at UCF has earned a reputation as an outstanding teacher-education program. A number of research and grant projects have provided much hardware and software during the past few years including computers, CD-ROM workstations, and interactive videodisc materials. The College has systematically provided computers for students, for staff, and for faculty as the budget would allow. Most faculty have access to a computer, with most offices housing two faculty and, generally, one computer. An Apple // lab is available as is an IBM lab. A grant from IBM provided a Token Ring network and a variety of educational software. During this year, a grant from Corning and Siecor provided wiring to every office and classroom in the building to increase connectivity.

Many College of Education faculty have long recognized the need to integrate computers into the teacher education curriculum. However, many faculty have limited expertise in the use of technology in teacher education or in public education since their careers and training did not include technology. While the feeling is strong that faculty need to model the use of technology in their courses, few have seen models to emulate. In addition, UCF is a young but growing institution whose leadership has put an increased emphasis on research and publications over the past decade, limiting the amount of time available to invest in learning about new technologies. Few faculty development opportunities are available on campus.

First Year

The presence of the Technology Instructor has impacted different faculty in different ways during this first year. This is primarily because of differing level of interest and expertise at the outset. It is important to note, however, that few faculty members remain unaffected.

The expert. Few faculty in the College of Education fall into this category. They are primarily the faculty who have training and degrees in instructional technology, or those who have long had an interest in technology and have acquired expertise on their own. While they have not frequently called upon the technology instructor during this first year, they have experienced change due to her presence. In previous years, these faculty were frequently consulted by other faculty, administrators, and staff for advice regarding the use and integration of technology. While few faculty objected to this informal advisory role, it was never an assigned activity. No released time was given, and many of the expert faculty found their time being spent in ways that were not productive to them. As one faculty member said, "In my next life, I'm not going to let anyone know that I know ANYTHING about computers."

The presence of an experienced full-time Technology Instructor whose time is designated to support faculty, staff, and administration has freed expert faculty to use technology for their own benefit, to learn more about technology, and to integrate it into their own curricula. In addition, these faculty have assisted the Technology Instructor in her adjustment to the college setting as mentors and understanding colleagues.

The Intermediate User. The faculty who benefited most from the Technology Instructor during this first year were the faculty who had a great interest in the use of technology, who had some experience with technology, and who had access to technological hardware and software. These faculty had questions they wanted answered, had some knowledge of hardware and software, and were most aware of their own need to become technologically literate before trying to integrate technology into the curriculum.

The Novice. Faculty who had the least experience with technology, faculty who had the greatest apprehension about technology, and faculty who had little interest in technology have all begun to show greater interest in using the Technology Instructor. She has made them feel comfortable in coming to her with questions, no matter how basic. Some simply needed help loading paper into their printers or dealing with DOS. Others needed to know how to use their word processing programs. Some needed to discuss basic compatibility issues, to learn about what was available within and outside of the college, and to learn basic terminology. A few who had experienced "techno-phobia" needed hand-holding while they used programs for the first time. Still others, many of whom were not using the technology because of lack of access or because of more pressing priorities, have seen what their colleagues have learned and have produced, and they, too are beginning to call on the Technology Instructor.

The Future

The primary activities of faculty and the Technology Instructor for the near future will emphasize the integration of technology into the teacher education curriculum. This will require finding appropriate instructional materials, developing materials, and revising present course content and delivery.

Interest in integrating technology among faculty remains high. The dedication of our faculty and the Technology Instructor to the task has provided much visibility for the College and for the faculty. Faculty are looking forward to increased connectivity with the College of Education LAN, other UCF LANs, the mainframe and beyond, but need training to realize its potential and its use. Faculty are also looking forward to becoming more productive and to enhancing their capabilities for research and professional presentations through the use of technology in a new faculty development area, with specialized equipment and software in a quiet area dedicated to faculty utilization.

The Technology Instructor's Perspective

Background

The position of Technology Instructor in the College of Education within the university was a challenge from the onset. As a newly created position in the college, it was apparent that a clearly defined job description had not been established. What was obvious was that the college was in need of someone who would be a resource to its faculty and staff with regard to technology. The types of questions asked during the interview revolved around experience using computers, the ability to locate software that could be incorporated into the curriculum, and the ability to work with faculty and staff to determine and meet their needs.

It became evident that much of what the faculty wanted to accomplish was hindered by several factors: the limited amounts of time, money, and hardware available to those interested. Whatever could be accomplished had to be done within these constraints.

The First Year

During the first four months, the Technology Instructor has worked with faculty who have expressed a need, concern and /or interest in the following areas: the installation of software; the use of software presentation packages such as Harvard Graphics in order to create a slide show or overhead transparencies; the use of authoring languages including HyperCard or Linkway to create interactive software; the implementation and administration of ICLASS on the college's LAN to provide classes the opportunity to preview and/or use the available software; the ability to gain access to the university's mainframe computer to use PROFS, CICS, and LUIS; the availability of hardware for classroom demonstrations; the availability of shareware or public domain gradebook, test-generator, and screen saver programs; the availability of appropriate software for the content of a specific teacher education course; and setting up a system in Departmental offices which make use of a variety of hardware platforms.

The Technology Instructor also became a liaison between the College of Education and Computer Services, a campus-wide support service for instruction and research related to computers. Computer Services is responsible for any work order requests involving moving computers, installing hardware and/or software, connecting computers to the mainframe, and maintaining LAN support.

Concerns for the most effective use of the equipment we have available to the college were directed to the Technology Instructor by the college administration. They asked, "What ways can we improve upon what we have in order to make technology more effective, taking the current economic constraints into consideration? What equipment is obsolete and should be surplused? What equipment is in need of repair or upgrading? How can we become a model for using technology so that our students will use it more effectively when they are in the elementary and secondary schools?"

The second semester has brought about an increase in the number of faculty who requested assistance. Hopefully, we are seeing the beginning of a "snowball" effect. The more people see what other faculty are doing and what can be done, the more they will want to accomplish on their own. The recent access to connectivity beyond the college and beyond the university is bringing more opportunities, more questions, and more potential for the college, its faculty, and its students.

The Future

The College has established a new faculty development area which provides a quiet, secure workplace for faculty. Although many faculty members have access to computers in their offices, each faculty member using the faculty development area has access to all three platforms (MS-DOS, Macintosh, Apple //), laser printers, a plotter, presentation packages, word processing and desktop publishing packages, authoring languages, utility programs, teacher utility programs, paint/graphics programs, and public domain programs. In addition, there is an area for faculty to meet with the Technology Instructor one-on-one or in small groups. This area has just been established, and it is anticipated it will receive heavy utilization.

The long range goal of incorporating the use of technology in the classroom will become more attainable in the next year. An understanding of the curriculum, methods, and content are necessary ingredients for the Technology Instructor to assist the faculty in accomplishing this goal. As individuals become more comfortable with technology and its applications for their own personal use, its role and benefits within the classroom will become more evident.

Conclusion

The infusion and integration of technology into a College of Education takes time, equipment, money, and a desire by the faculty to accomplish. It is essential that support be provided to reach this goal. A number of grant opportunities have been made possible because of the presence of technology, the Technology Instructor, and the college's focus on integrating technology into the teacher education curriculum, and faculty and staff are beginning to reach the comfort level in learning about technology. They agree that integration into the curriculum is the next step. The faculty firmly believe their efforts, with assistance from the Technology Instructor, will ultimately enhance teaching, research, and service opportunities and will provide the profession with teachers who are prepared to reform and restructure our schools through technology.

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SIMULATIONS

Introduction

The past ten years have been an exciting time for those of us who have been developing computer simulations to help preservice teachers acquire basic professional skills. It seems like yesterday that at the Curry School we were using a then state-of-the-art 48k OSI Challenger II microcomputer to run a simulation which enabled our students to maintain simple dialogue exchanges with a class of four simulated pupils (Strang & Loper, 1983-1984). Of course, each time we individually administered this simulation, we also had to rely on the services of two fully trained operators. And now, the current Curry Teaching Simulation, using an off-the-shelf MS DOS microcomputer, allows our students, with little or no operator support, to engage individually in a variety of ways with larger classes of pupils, each of whom is capable of exhibiting a far greater array of verbal and nonverbal behavior.

Continuing advances in technology, coupled with systematic research efforts, have allowed for rapid improvements in the quality and versatility of computer-based teaching simulations. The three papers in this section illustrate both current progress and future aspirations in this area.

At Bowling Green State University, Charlotte Scherer is exploring how Hypercard tutorials and MECC interactive videodisc programs can best be used to improve lesson planning skills. At the University of Virginia, we are continuing to develop and to field test a self-administered simulation which addresses both teaching and behavior management skills. In this section, we will describe preliminary research directed toward assessing this simulation's usefulness as an inservice diagnostic tool. And at East Carolina University, Rebecca Brent and her colleagues are testing a variety of simulations in their elementary teacher education program. These simulaions include Dee Anna Willis' IRIS, a tool designed to train students how to administer a popular reading inventory; the previously cited self-administered Curry Simulation; and PLUS, a software package which is being designed to teach lesson planning skills.

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Developing a HyperCard Tutorial and Interactive Videodisc Program to Teach Lesson Planning

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Introduction

Interactive Videodisc (IVD) as a technological medium for education has grown gradually during recent years. Many recent studies with learners of varying ages (Carlson, & Falk, 1989; Char & Tally; Dalton, 1986; Dalton & Hannafin, 1987; Leonard, 1989; Savenye & Strand, 1989; Shyu & Brown, 1990) indicate effective results with IVD. Among the major marketers of videodiscs for K-12 education is the Minnesota Educational Computing Corporation (MECC) which lists in its latest IVD catalog more than a hundred videodiscs appropriate for use with K-12 students. The advent of Hypercard (for the Macintosh computer) and Linkway (for the IBM) makes it much easier to access videodisc content through a computer program. Also, barcode readers allow entire lessons to be listed as barcodes and read with a handheld barcode reader. This technology allows access to appropriate segments from a videodisc for teaching a specific lesson in any desired subject area.

Given this expanded use of interactive videodisc technology, it seems crucial for preservice teachers to become aware of the potential of this new medium and to become comfortable with its classroom use. Although some institutions are beginning to explore the potential of interactive video technology for preservice teacher education programs, few research studies have appeared in the literature.

Of the studies that have been reported, several have employed videotape rather than videodisc technology. Videotape technology has proved successful for helping students assess teaching behaviors (Volker, Gehler, Howlett & Twetten, 1986) and for developing teaching skills through simulations (Rogers & Rieff, 1989). In one study that did use videodisc technology, preservice teachers created their own videodisc instruction modules using an authoring system. The kinds of questions asked by novices were investigated and it was found that although at least three forms of questioning were used, the primary form used was the multiple choice question (Smith, 1988). In another report, Pollak & Breault (1987) describe the videodisc package used for the present project, MECC's *Improving Teacher Effectiveness* (1986), as a potential source for helping teachers improve their effectiveness by seeing models of good classroom instruction techniques.

Past experience with helping teachers learn about the educational uses of computers has taught us that the first step is for teachers to become comfortable using them for their own purposes: writing lesson plans, grading papers, creating handouts. If teachers are comfortable, they are much more likely to use the computer for instructional purposes in the classroom. Therefore, if we expect to prepare preservice teachers to use IVD resources in their classrooms, we must provide them opportunities to use this media for their own learning purposes. At Bowling Green State University, in the Clinical Experience Lab of the College of Education and Allied Professions, we concluded that one way to accomplish this was to create effective teaching and lesson planning tutorials that employ IVD technology. These tutorials would then be used for required coursework assignments.

The Effective Teaching and Lesson Planning IVD Project

Initially, we purchased the MECC *Improving Teacher Effectiveness* videodisc (1986) to demonstrate the potential of IVD. This package came with two Apple IIe computer program tutorial disks. One disk focuses on presenting four broad, effective teaching strategies: teaching to the objective, getting student participation, developing focus on learning, and increasing intent to learn. Associated with these strategies are several subskills, such as stating the objective, providing relevant information, asking relevant questions, responding to student efforts, active student involvement, level of concern, and knowledge of results. For each subskill, the tutorial references a short lesson segment on the videodisc depicting the particular teaching strategy. The videodisc includes eight of these short lesson segments, along with several text screens that define terms and state principles. This particular tutorial also provides opportunities to use a "video dictionary" and to label characteristics of a lesson. Thus, this Apple IIe interactive videodisc program teaches effective teaching strategies through a variety of means.

At first, students from two classes were assigned to view the IVD resource as one of several innovations in education. Then, we decided to be more deliberate about assigning students to use this resource. The instructor of the required computer course for elementary majors thought it would be useful to assign his students to complete at least one part of the tutorial. This requirement has been in effect for the past two semesters, and we think that this assignment has helped these students become aware of the potential of IVD while teaching them about effective teaching research and strategies.

The second tutorial disk included with the videodisc package is designed to help students plan lessons using effective teaching strategies. It reminds students of the various parts of a lesson plan and helps them to incorporate the effective teaching strategies as a lesson is planned. Because this computer disk incorporates word processing capabilities, students can create a lesson plan while using this guided tutorial. MECC originally intended to develop this program to remind students of a particular effective teaching strategy by accessing a segment of a live lesson from the videodisc. However, when we were unable to get our computer disk to access the videodisc, we contacted MECC. Representatives of MECC stated that they had never completed this part of the program and indicated they had no plans to do so.

Coincidentally, Hypercard became prominent as a way of interacting with a videodisc using a Macintosh rather than an Apple IIe computer. Because our lab had both machines, it seemed logical to use MECC's idea and create a Hypercard tutorial that would help students plan a lesson and also access exemplary segments from the videodisc. Our next step was to create a Hypercard tutorial that would help our students use the effective teaching strategies presented on the videodisc when they planned lessons. One of our undergraduate employees, a computer science programmer who is especially good with Hypercard, agreed to work on the project.

Creating the Lesson Planning Tutorial

Initial development

We gave the programmer the tutorial materials from MECC. Once he understood our goals, he drafted a Hypercard stack and programmed "buttons" that would access the videodisc. To interface the Macintosh computer with the videodisc player, he used the *Voyager Video Stack* (1988) available from The Voyager Company. Meanwhile, this author searched the MECC videodisc and tutorial to identify the desired frame numbers for each lesson segment or text screen.

Once again we approached the course instructor. Because, in addition to assigning the effective teaching strategies IVD module, he also assigned students to write lesson plans incorporating computers as part of a regular curricular lesson, his students were likely candidates for using this IVD planning tutorial. He was enthusiastic about using this new program for the planning assignment and he decided to pilot this project with a portion of his Spring 1991 students.

Revisions

The programmer then revised the drafted tutorial stack based on additional materials: a summary of Rosenshine's and Stevens' instructional functions to help teachers structure a direct teaching lesson while incorporating effective teaching strategies. The source of this summary was the teaching strategies chapter of *Dynamics of Effective Teaching* (Kindsvatter, Wilen, and Ishler, 1988).

When the first version of the Hypercard tutorial was completed, the course instructor and this author decided that the lesson plan shell as drafted was not sufficiently generic to serve the purposes of the course assignment. Because this course is usually taken before the students have learned formal lesson planning in methods courses, the instructor thought that students should write plans more eclectic in nature, drawing from a number of approaches and even adapting from now readily available plans that incorporate computers into curriculum subject areas. In fact, his guidelines for this assignment were adapted from an outline of a computer lesson plan taken from *My Students Use Computers* (Hunter, 1983). These ideas were incorporated into the next draft, which was reviewed and checked for clarity and consistency. Revisions were made to clarify the directions to the student and to provide further options for using the videodisc at appropriate points during the creation of the lesson plan.

Saving and printing lesson plans

Finally, the programmer wrote routines to allow for saving the plans to disk and for printing the completed lesson plan. The print routines turned out to be more difficult than earlier imagined because of Hypercard, time, and budget limitations and the desire to make this program as user friendly as possible. We wanted the plans to be printed in a particular format. We also wanted the students to be able to save the plan, load it back into the tutorial or edit it from a word processor as desired without having to go back to the tutorial, and to have a file that could be adapted to another lesson plan. Hypercard's print routines make this combination of desires more difficult to achieve than we had anticipated. Even the new 2.0 and the developer's package (which was not yet available at the time this project began) would not solve all the problems without considerably more time and money than we had available. As a result, we compromised and decided on a simpler but acceptable format for the printout. Students can save a file and reload it into the tutorial for further editing. They can also save the plan as a MacWrite file, but the two files are not compatible. With the MacWrite file, they can modify the plan without having to go back through the tutorial. They can also print out the plan from the Hypercard tutorial or the MacWrite program. This latest version was reviewed by the instructor, this author, and the course graduate assistant who would also train the students to use the IVD or Hypercard tutorials.

Additional features

When we realized we had forgotten provisions for rereading or modifying previous cards, and that we had not allowed for saving work and exiting at any point, we added these features. Then we discovered that when the file was printed from Hypercard, it would disappear and the file would be blank, unless a number of variables were saved in a different way. A programming modification remediated this problem.

Final Results

The final result of this ten-month process was a Hypercard stack that assists students first to write a cover sheet with all the usual demographic data (i.e., student's name, lesson title, course, grade level, subject area), a short summary of the lesson content, the assumed computer hardware and software availability, and a bibliographic source for the computer lesson plan they are adapting. Then, the stack proceeds to guide the student through developing a goal and some specific objectives. Materials from the videodisc may be called up at this time to aid the completion of this part (i. e., ensuring relevance of the objectives, and planning an appropriate way to introduce the lesson and state the objectives to the students when implementing the plan). Next, the students are asked to list materials needed and then to think about prerequisite computer skills and knowledge needed by the students learning the lesson.

Following this preliminary component, the tutorial introduces information about anticipatory set and the students then have the opportunity to access a segment from the videodisc that demonstrates a teacher using anticipatory set in a lesson. Next, the students are asked to provide a description of the software used in the lesson, and a narrative description of the major activities of the lesson. For this part, the students choose among three approaches: modeling, guided practice or independent practice. The students may choose to incorporate any combination of approaches that seems appropriate for the topic covered. Here guidance comes from the Hypercard tutorial, the videodisc teaching segments and the text screens on the videodisc. The students then are asked to plan for closure of the lesson, again with opportunity for videodisc help. Finally, the students plan an evaluation component of the lesson (formal or informal or both) for which another videodisc example is accessible. Once the plan is completed, it may be either saved to disk or printed or both.

The Research Design for the Pilot Project

As stated earlier, this Hypercard interactive video tutorial will be piloted with a portion of the students in the computer education course during spring 1991. This course is taught in several sections so it will be relatively easy to assign some students to use the interactive videodisc tutorial, others to use just the Hypercard tutorial and still others to serve as a control group, producing their lesson plans in the usual way. For this pilot project, approximately 25 students will be randomly assigned to Experimental Group 1, using the IVD, and another 25 will be randomly assigned to Experimental Group 2, using the Hypercard tutorial only. The remaining approximately 100 students will serve as a control group. Because using the videodisc is time consuming and the Hypercard tutorial is helpful in its own right, both the author and the course instructor are ready to test both strategies for their effectiveness. All students will have an opportunity to use the Apple IIe tutorial and videodisc to acquaint themselves with the medium and with the effective teaching strategies. Groups using the IVD or the Hypercard lesson planning tutorials will have a special training session to acquaint them with the materials and their use. Because the students already use the Macintosh and MacWrite for their written assignments, the transition to using the Hypercard stack and clicking the mouse on a "button" to access the videodisc should be easy.

For the purposes of this study, the lesson plans created by all three groups will be graded by a team of trained raters. Criteria for grading will include such things as use of modeling, guided practice, or independent practice, clarity of objectives, incorporation of particular ways to teach to the objective, and design of the anticipatory set of the lesson. Numeric assessments will be assigned to each graded plan. Differences in the scores for these plans will be analyzed statistically, testing the null hypothesis that there will be no significant differences among the mean scores of the groups. Should significant differences be found, additional analyses will be performed. In addition to looking at the lesson plans, all students using each of the tutorials will be given a pre- and post-Likert scale attitude questionnaire to determine their attitude toward technology. The results of these attitude tests will be statistically analyzed to test the null hypotheses that there are no significant differences between the groups on either the pretest or posttest and that there are no significant changes in the scores of each group and among the three groups.

For the two groups using the Hypercard tutorial or the IVD program a short questionnaire regarding the use of the medium itself as an aid to lesson planning will be completed. Results of this questionnaire will be analyzed and incorporated into the entire set of results from the pilot study. Personal interviews with a portion of the students from each of the three groups will also be held to gather further information regarding the use or non-use of these tutorials as an aid to their lesson planning. We will also track the frequency of videodisc access by the IVD group through the use of an internal counting program. This count will be printed out as a code on the coversheet. Thus, we will have some idea as to whether students actually used the videodisc very often in creating their plans. A short post quiz on the effective teaching strategies studied in both the Apple IIe IVD assignment and the technology-based lesson planning assignment might determine whether indeed they have more knowledge about the strategies from using these tutorials. Thus, all three groups will be given quizzes on these strategies and the results of these quizzes compared for differences between the groups. Statistical analyses will be performed to test the null hypothesis that there are no significant differences between the groups with regard to scores on a posttest.

Results from this pilot study will be used to refine the tutorials and to determine further uses for the programs. The use of either the Hypercard tutorial or the IVD program with other students will entail the purchase of additional equipment. Given the results of other research on use of computers or IVD for educational purposes, it seems fairly likely that there will not be significant differences between the groups in terms of quality of lesson plans produced for an assignment for a required course. Most students will probably do their best, regardless of how much help they get. However, it does seem likely that those using the Hypercard and/or IVD tutorials might have more positive attitudes about the assignment and might indeed incorporate more of the effective teaching strategies in their lesson plans. They might also tell us that they find the tutorial a helpful guide. The final step will be to report the research results. These results will be the subject of another paper.

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The Curry Teaching Simulation: A Window on Effective Teaching Skills?

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Introduction

Over the past decade, computer-based simulations developed at the Curry School have been used to train a variety of basic instructional and behavior management skills to over 600 preservice teachers (see Strang & Loper, 1983; Strang, Badt, Loper, & Richards, 1985; Strang, Kauffman, Badt, Murphy, & Loper, 1987). Our most recent efforts have focused on creating a teaching simulation that requires minimal computer and personnel resources—a simulation that runs on an off-the-shelf MS-DOS microcomputer and that can, with little outside assistance, be self-administered by each participant. In training sessions using this tool, preservice teachers have increased their use of instructional skills such as introducing content via think-time prompting and remediating content errors via item-specific prompting (Strang, 1990; Strang, Landrum, & Ulmer, 1990). In addition, participants in these initial field tests have increased their use of effective misbehavior intervention techniques such as involving misbehaving pupils in lesson-related activities and also have decreased their use of ineffective intervention practices such as engaging misbehaving pupils in off-task conversations. The present study explores another important possible use of the self-administered simulation—its potential as a diagnostic vehicle for assessing both instructional and behavior management skillfulness in inservice teachers.

Research Study

Preliminary research is focusing on a fundamental question relevant to the self-administered simulation's diagnostic potential: Do professional teachers exhibit more skillfulness both in teaching content and in managing misbehavior in the simulated-teaching environment than participants who have had neither training nor experience in teaching?

Method

Subjects

To answer this question, two distinct groups of subjects were selected. One group consisted of 12 professional educators; the second group consisted of 12 subjects whose professional focus was in an area outside of teacher education. Subjects in the former group had taught for an average of 7.1 years (range = 1 to 15 years). None of the subjects in the latter group had had any academic coursework in teacher education and none had ever worked as classroom teachers.

Teaching a simulated class

In individual sessions, each subject was asked to assume the role of a teacher in conducting two back-to-back spelling lessons with classes of 12 pupils each. Via a one-page pre-teaching information sheet, each teacher was instructed to focus on reviewing a spelling assignment (24 words on an accompanying sheet) so as to prepare the class for an upcoming examination. Lesson characteristics were "preset" so that each teacher's class was comprised of pupils, most of whom had not completed their homework assignment and also were "predisposed" to exhibit high rates of common misbehaviors such as daydreaming, unauthorized leaving of seat, and talking out.

In conducting a lesson, the teacher maintained a dialogue with a class of pupils who were graphically represented on a monitor. A menu of potential teacher interaction options and their entry codes also appeared on the right third of this screen. The lesson progressed as the teacher communicated desired menu options to pupils via keyboard input--options which immediately produced pupil or class reactions. Pupil verbal responses appeared as text beneath a targeted pupil's name; hand raising and nonverbal misbehavior actions were depicted by obvious graphical cues (e.g., a daydreaming pupil's eyes disappeared). As the screen changed to reflect pupil reactions to teacher actions, a new series of menu options appeared and the teacher continued the dialogue sequence. The following example illustrates the simplest type of teacher-pupil dialogue exchange.

Teacher action: Enter [F] + [T] + [1 & <CR>] to ask FRANK to TRY to spell the assignment word #1 which is ACCOUNT.

Pupil reaction: Frank responds A-C-C-O-U-N-T.

Teacher action: Enter [G] + [Y] + [.] to inform this student, "You have made a GOOD TRY, and YOUR spelling is correct."

During many of these interaction sequences, or events, pupil reactions to teacher actions served either as positive reinforcers or as punishers for the teacher actions that they followed. For example, if the teacher asked a prepared pupil to assist an unprepared pupil with a spelling word that the latter pupil had just missed, this teacher action would be reinforced by the erring pupil's "learning to spell" that word. On the other hand, if during attempts to quell misbehavior outbursts, the teacher tried to stop a pupil's wandering around the classroom by using a sharp reprimand, the pupil immediately punished this action by emitting a sarcastic reply.

A lesson consisted of a chain of 80 events—each offering the teacher the opportunity to make a decision as to how best to teach lesson content or, if beset by pupil misbehavior, how best to remediate such actions. Two preset functions were responsible for the creation of a very demanding teaching environment. First, 9 of the 12 pupils in the class were preset to be unprepared to spell correctly any of the assigned words. Second, 6 of each of the 3 types of misbehaviors were preset to occur at spaced intervals during the lesson.

Choosing variables and receiving feedback

Directly following each lesson's 80th event, the teacher completed a software-driven self-evaluation. At the onset of this activity, the teacher was provided with a booklet listing 30 variables, each of which defined a quantitative measure pertaining to the preceding simulation experience. This list included 10 variables which addressed general lesson features (e.g., number of different words introduced), 10 variables which addressed the teaching of content (e.g., the average number of times that the teacher devoted to a spelling word before introducing the next item), and 10 variables that addressed the intervention of misbehavior (e.g., the frequency with which the teacher involved a misbehaving pupil in lesson-related activity). From this list, the teacher selected 5 variables of greatest personal interest. After keying appropriate variable codes into the computer, screen displays prompted the teacher to make a series of keyboard entries of quantitative values representing self-perceptions for each of the selected variables. This activity was immediately followed by a screen display which presented the actual and rated values for each of the selected variables (see Figure 1).

After viewing this display, the teacher was introduced to a new spelling list and asked to conduct a second 80-event lesson with a class of pupils who differed only in name from their predecessors. Immediately following the self-evaluation and feedback phase of the second lesson, the teacher received a final debriefing and then completed a questionnaire comprised of items which addressed the realism and value of the experience.

Results

Lesson performance

To test for group differences in teaching performance, eight measures of teacher-pupil interactions that had been generated during the lessons were submitted to parametric statistical analyses. Table 1 presents descriptive statistics for these variables.

An inspection of lesson main effects (lesson 1 versus lesson 2) for the four instructional variables revealed that subjects in both groups increased their use of helpful clues ($F(1,22) = 8.46, p<.01$) and praise for effort ($F(1,22) = 10.07, p<.01$) immediately following pupil errors. An examination of the group main effects (experienced teacher group versus control group) for these measures revealed that experienced teachers used more "think time" instructions in introducing content than did the control subjects ($F(1,22) = 4.57, p<.05$); they provided

Lora Adams	11-20-90	ID/SESS/TYPE: 254/1/Spell
Fdbk type: tea-set	Self-rate: y	Norm-fdbk: n

SUMMARY TABLE	Rated	Actual
1. VOLUNTEER COUNT: the number of times that the teacher asked the class for volunteers to answer a question	4	2
2. ENCOURAGEMENT COUNT: the number of interactions in which the teacher offered encouragement to a pupil or to the class	15	27
3. TEACHER FEEDBACK COUNT: the number of times that the teacher personally provided accuracy to a pupil who had just answered	30	12
4. ITEM PERSISTENCE: the average number of interactions that the teacher devoted to a content item before the next item was presented	10	4.2
5. LESSON INVOLVEMENT COUNT: the number of times that the teacher involved a misbehaving pupil in lesson-related activity	17	9

Figure 1. Summary Record Post-lesson Display

more helpful clues and prompts immediately following pupil errors ($F(1,22) = 9.66$, $p<.01$); and they were less likely to evoke additional spelling errors during their intervention attempts with erring pupils ($F(1,22) = 4.57$, $p<.05$).

A review of lesson main effects for the four misbehavior variables revealed that subjects in both groups showed across-lesson improvement in effectively initiating misbehavior intervention actions ($F(1,22) = 4.99$, $p<.05$). An examination of the group main effects for the misbehavior intervention variables indicated that the experienced teachers were less likely than their control counterparts to "abruptly end" content-related interactions in order to address misbehaviors ($F(1,22) = 13.39$, $p<.01$). When they did intervene, experienced teachers were more likely to effect an immediate cessation of the misbehavior ($F(1,22) = 7.93$, $p<.025$), and, in effectively intervening, they were more likely to employ unobtrusive physical proximity and touch intervention techniques ($F(1,22) = 19.62$, $p<.01$). Finally, F-testing produced no significant main or interaction effects for the variable defining the overuse of effective intervention techniques.

Post-lesson performance estimations

A review of the post-lesson self-evaluation data revealed great diversity in subjects' selection of variables. Each of the 30 variables was chosen at least once during the two post-lesson selections by at least 2 of the 24 subjects. Subjects in both groups varied widely in repeating variable choices during second post-lesson selections. While across-lesson "variable repeats" averaged 50% for the experienced teachers, individual selection patterns ranged from 0% to 100%. Repeated selections averaged 40% for the control subjects with individual selection patterns ranging from 0% to 80%.

No evidence was found that subjects in either group selected variables on the basis of their inclusion in the general, teaching or misbehavior intervention variable clusters. Clear patterns emerged, however, when choices were viewed on the basis of inclusion in categories representing the use of *effective* skills (e.g., offering encouragement to a pupil) versus the use of *ineffective* procedures (e.g., expressing displeasure with a pupil's performance). Both experienced teachers and control subjects were more likely to include, in the two 5-item lists that they generated during their post-lesson selections, more variables from the 10 effective options than

Table 1
Means and Standard Deviations for Performance Variables

Variable	Type	Exp tch group Lsn 1	Exp tch group Lsn 2	Control group Lsn 1	Control group Lsn 2
Probability that teacher used "think time" to introduce a new word	I	.34 (.37)	.35 (.31)	.10 (.18)	.15 (.20)
Probability that teacher gave erring pupil a helpful clue immediately following an error	I	.56 (.36)	.67 (.32)	.17 (.21)	.35 (.31)
Probability that teacher gave immediate encouragement to an erring pupil	I	.20 (.19)	.30 (.33)	.17 (.24)	.43 (.35)
Probability that teacher evoked additional spelling errors while trying to help an erring pupil	I	.11 (.12)	.11 (.12	.18)(.16)	.17 (.16)
Frequency with which teacher abruptly ended a content-related event to address a misbehavior	M	.83 (.94)	1.25 (1.14)	3.08 (1.78)	3.17 (2.98)
Probability that teacher was effective in an initial attempt to intervene a misbehavior	M	.79 (.09)	.83 (.10)	.65 (.13)	.74 (.16)
Probability that when teacher employed an effective technique it would involve touch/proximity	M	.41 (.12)	.41 (.12)	.19 (.15)	.17 (.18)
Frequency with which teacher overused an effective technique while intervening misbehavior	M	3.67 (2.27)	4.33 (2.84)	4.50 (2.50)	4.92 (3.92)

Note. Parentheses designate standard deviations. Each group contains 12 subjects.
I = instructional variables, M = misbehavior intervention variables.

variables from the 10 ineffective options ($t(22)=3.17$, $p<.01$ for experienced teachers; $t(22)=2.72$, $p<.02$ for control subjects). Three "effective" options clearly emerged as favorite choices. More than 50% of both experienced teachers and control subjects included at least once in their lists those variables which defined (1) how frequently the teacher had used encouragement, (2) how frequently the teacher had offered accuracy feedback, and (3) how frequently the teacher had involved misbehaving pupils in lesson-related activities.

A comparison of self-perceptions of lesson values with those actually recorded revealed that subject estimations were typically inaccurate. An average of only 28% of the 90 first-time estimations that experienced teachers made during the two post-lesson self-evaluations fell within an accuracy range of plus-or-minus 25% of the recorded values for the lesson variables that they represented. Only 32% of the control subjects' 93 first-time estimations met the accuracy criterion. As for individual subjects' estimating accuracy, only 1 experienced teacher and 3 control subjects achieved the accuracy criterion for at least 50% of their first-try estimations.

One clear group difference resulted from the analysis of estimation accuracy data. Experienced teachers who repeated variable choices during their second post-lesson selections were more likely than their control counterparts to maintain for a majority of their second estimations either perfect accuracy which mirrored a lesson 1 estimation or to improve in accuracy when a lesson 1 estimation had been inaccurate. Eight of the 11 experienced teachers who repeated choices either maintained a perfect estimation accuracy or improved in accuracy on a majority of their second estimates. Only 2 of the 10 control subjects who repeated choices mirrored such performance.

Post-participation questionnaire results

On a paper-and-pencil questionnaire which all subjects completed at the end of the debriefing, 83% of the experienced teachers and 92% of the control subjects rated the simulation as being "realistic." Regarding its value in teacher education, 75% of experienced teachers and 100% of the control subjects deemed the simulation to be "an effective tool for training teachers." Finally, 92% of the experienced teachers and 100% of the control subjects judged the simulation experience "useful for beginning teachers."

Summary of major findings

Several strong lesson main effects attest to the simulation's skill-training impact on both experienced and control subjects. Regarding teaching, subjects in both groups showed across-lesson increases in offering erring pupils immediate encouragement for effort and in providing helpful clues. Regarding misbehavior intervention, subjects in both groups showed across-lesson improvements in initial attempts to remediate misbehaviors. These across-lesson improvements in teaching and in misbehavior intervention paralleled those that had been achieved by preservice teachers who completed earlier versions of the teaching simulations (Strang, Landrum, & Lynch, 1989).

Turning to the central focus of the study, the performance results also reveal sharp differences concerning the way in which the experienced teachers and the control subjects conducted their lessons--differences that portray the experienced teachers as more effective both in teaching lesson content and in managing classroom misbehavior. In teaching, the experienced subjects introduced content more effectively through the use of "think time" prompting and also provided more productive remedial assistance to erring pupils through the use of helpful clues and actions that minimized future errors. Regarding classroom misbehavior, the experienced subjects were less apt to interrupt content-related dialogue in order to initiate a disciplinary action. When they did intervene, their initial actions were more effective than those exhibited by subjects in the control group. Finally, in quelling misbehavior, experienced subjects were more likely than control subjects to employ the unobtrusive technique of approaching and/or touching the misbehaving pupil.

In interpreting the above results, it is important to note that individual professional teachers showed considerable variations in the way in which they interacted with their pupils. Specific differences were found for a variety of teacher actions including soliciting pupil volunteers, requiring erring pupils to emit correct answers before new content was introduced, and directly intervening misbehaviors via rule recitation requests.

Subjects in both groups showed wide diversity in selecting variables for self-evaluation and feedback. The sole predictable pattern in their selection centered on a preference for variables that addressed their skillfulness over those that addressed their shortcomings.

Replicating the findings of Strang, Badt, and Kauffman (1987), and Strang, et al. (1990), subjects from both groups were usually inaccurate in initial attempts to quantify lesson-related variables. When estimations for the same variable were repeated following lesson 2, however, the experienced teachers typically demonstrated the improved estimating accuracy found in preservice teachers who had participated in the previous research. The nonteacher control subjects in the current study typically did not show such improvement.

A New Generation

Efforts are already under way to field test an enhanced version of the simulation that was employed in the current study. This version contains important innovations which we anticipate will strengthen its diagnostic usefulness. First, a "warmup" option has been added to provide participants with an opportunity to practice interacting with a simulated class prior to the first lesson. In addition, realism in the teaching of lesson content has been increased through the addition of a text-insert option. When enacted, this option allows the teacher to author specific text passages while communicating with pupils at the onset of the lesson, during prompting exchanges following content errors, and at the end of the lesson.

The simulation's misbehavior component has also been upgraded in several important ways. The preprogramming of misbehavior occurrences during the lesson has been expanded to include intense cluster patterns. Additional software enhancements offer the teacher several new choices for effectively intervening misbehavior. A teacher can now reinforce good class deportment and can thus forestall future outbursts of misbehavior. A teacher can also employ timeout procedures and use the effective technique of eye contact to intervene out-of-seat and talkout misbehaviors.

Many of the innovations in the latest simulation represent the implementation of ideas gleaned from two sources. Over the past two years, members of the education faculty at several southeastern institutions have been field testing various versions of the simulation with their preservice teachers. These partners have provided us with valuable quantitative data and, at several workshop sessions, with sound professional insights for improvements. In addition, experienced teachers, preservice teachers, and nonteaching professionals who have completed the self-administered simulation at the Curry School have, during their debriefings, often provided us with helpful suggestions for increasing the simulation's realism.

Our latest simulation's skill-training attributes will be assessed as this tool is used in preservice teacher training at the Curry School and at partner sites. Based on the encouraging results achieved in the pilot research, we will also attempt to define more fully the simulation's diagnostic potential. Finally, with a larger pool of experienced teachers, we will begin to explore the variations that experienced teachers use, particularly in presenting lesson content and in assisting erring pupils.

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Integrating Concrete-Modeled Experiences into the Elementary Teacher Education Curriculum

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For Cruickshank (1986) instructional strategies used in teacher education fall into four general categories: (1) *Concrete-real*, which involves "direct first-hand experience" such as student teaching; (2) *Concrete-modeled*, which involves participation in simulated teaching experiences such as microteaching and computer simulations; (3) *Vicarious* or "indirect second-hand experience," which centers on observations of others' teaching; and (4) *Abstract* or "third-hand experience," which includes lectures, case studies, discussions, traditional computer-assisted instruction, and recitations. Despite the fact many professional skills are best learned through concrete experience, teacher education programs commonly rely upon abstract instructional strategies (Cruickshank, 1986; Smith, 1987). Undoubtedly, one reason for this is that abstract instructional methods can be planned and implemented with relative ease while concrete-real methods, which require the location of suitable field placements and the maintenance of external supervision programs, are expensive and time consuming.

There are, however, ways to approach concrete experiences with a minimum outlay of expense and time. The concrete-modeled strategy offers the teacher educator a variety of useful instructional methods. These include microteaching, role-playing, and—notably—computer simulation (which we will simply term simulation). The simulation method offers a number of particularly attractive features:

1. Simulations can easily be structured to provide instruction in content knowledge, instructional methodology, lesson planning, and classroom management.
2. Simulations furnish any desired mixture of variety and repetition in the lessons taught and problems posed.
3. Simulations enable students to work at their own pace at convenient times.
4. Perhaps most importantly, simulations provide students with a safe, non-threatening environment in which to make mistakes and receive corrective feedback.

Although computer simulations in various forms have been used in teacher education for nearly 30 years, early efforts were labor intensive and costly (Smith, 1987). With the increased availability of microcomputers and user-friendly authoring software during the 1980s, interest in this approach has intensified. Relatively few working simulations, however, have been developed for teacher education (Willis, in press)

This paper outlines a general approach for the development of classroom simulations, summarizes the resources and procedures needed to integrate simulations into the teacher education curriculum, and describes simulations that are either in use or under development at

˜ast Carolina University. The simulations discussed deal ·· h the administration of a reading performance assessment instrument, the management of classroom behavior, and the implementation of lesson-planning models.

Integration of Concrete-Modeled Experiences into the Curriculum

Certain conditions must exist before concrete-modeled experiences can be effectively integrated into teacher education curricula. There must first be a perceived need for such experiences. Often this need becomes apparent early in the student teaching program, when supervisors discover that students are having difficulty planning lessons, making instructional decisions, or managing their classrooms. Difficulties often result from students' inability to relate the abstract material in their methods courses to the concrete reality of their field classrooms. At this point, the desirability of providing simulated experiences to ease the transition from the college classroom to the school classroom becomes very apparent. Cruickshank (1986) addresses this issue, suggesting that concrete-real instructional methods such as student teaching would be much more effective if they were preceded by concrete-modeled experiences such as simulations.

Once the need for a simulation has been identified, a number of technical problems must be solved. Software must be found or developed that is congruent with the theoretical stance of the teacher education program; technical and financial support must be provided to adapt and maintain the software on available computer equipment; and instructional resources must be committed to assure that both student and faculty users of the software know how to run the simulations and how to interpret the feedback.

One way of approaching the development of a simulation and its integration into a curriculum is the Four D instructional development model authored by Thiagarajan, Semmel, and Semmel (1974). This model has four stages: (1) *Define* (evaluate the need, specify the target population, define the development task, divide the development task into subskills, and specify the instructional objectives); (2) *Design* (design and construct a prototype set of instructional materials—the software in the case of computer simulation); (3) *Develop* (evaluate the prototype by securing expert opinions and testing it with students representative of the target population, revise the prototype in accordance with the feedback received, and perform summative evaluation); (4) *Disseminate* (complete a summative evaluation, package the final product, distribute it to the appropriate users, and provide training and support). The application of this approach to the development of simulation packages for teacher education is illustrated in the next section.

Computer-Based Simulations at East Carolina University

A group of teacher educators at ECU became interested in using simulations to provide concrete-modeled experiences for their students. Funding from the ECU administration and a grant from IBM for a Teacher Education Computing Center provided the hardware and software used to develop the simulations and the computer environment where students could use them. The goal was to create simulations that would serve as additions to the concrete-real experiences afforded by student teaching in local public schools. In the remainder of this paper, we describe two simulations currently in use in the elementary teacher education curriculum and then discuss a third simulation which is being developed.

Informal Reading Inventory Simulation (IRIS)

The *Burns & Roe Informal Reading Inventory* (IRI) (Burns & Roe, 1985) is a widely used diagnostic tool for the evaluation of reading performance. One East Carolina University faculty, Dee Anna Willis, developed a simulation to provide students with the opportunity to practice administering the IRI before they tried to use it with real subjects. The steps in the Four D model of development applied to this simulation were as follows:

Define. The desirability of providing practice in the use of the IRI was recognized. After a search for existing software was unsuccessful, in-house development of the software was begun.

Design. The *Informal Reading Inventory Simulation* (IRIS) was designed and a preliminary version was written using Authorware, an authoring system that greatly simplifies the process of coding instructional simulations (Authorware, 1988).

Development. The prototype version of IRIS was tested by members of the reading and instructional technology faculty and students at ECU. Revisions were made based on their criticisms and suggestions. Summative evaluation of the revised package then took place in a controlled research study that involved the random assignment of 35 students from two reading classes to either a simulation or a control group. Results indicated that students completing the simulation scored significantly higher on a test of IRI administration and scoring skills than did students in a control group.

Dissemination. Information about IRIS was informally shared with all instructors of the reading course, who then incorporated it into their classes. Currently, the instructors introduce the IRI in class, teach its elements and provide guided practice in its use. Students then use

IRIS on their own in a supervised computer laboratory, "administering" it to hypothetical subjects and interpreting the results. They may practice as often as they wish until they deem that they have mastered the use of the instrument. Future plans include creating additional simulated students who represent a range of grades, levels of reading proficiency, and types of reading problems, and then making the simulation available to teacher educators at other colleges and universities.

Curry/Strang Teaching Simulation

In reviewing the literature on the use of simulations in teacher education one name consistently appears - that of Harold Strang (see Strang, Badt, Kauffman, & Maggio, 1988; Strang, Landrum, & Lynch, 1989; Strang, Landrum, & Ulmer, in press; and Strang & Loper, 1983). Using the *Curry/Strang Teaching Simulation* developed by Harold Strang at the University of Virginia's Curry School of Education, teacher education students individually teach a class of 12 software-defined pupils who periodically talk out, daydream, and leave their seats without teacher authorization. Via menu selections, each participant employs instructional strategies in teaching spelling or math content while attempting to control outbursts of pupil misbehavior. The education students generally "teach" a warm-up lesson to familiarize themselves with the computer keyboard and the simulation's sequence of events. Next, they "teach" two lessons. Each lesson ends when a predetermined number of events have occurred. (An event is a teacher-student or teacher-class interaction.)

Define. Supervisors at ECU, observing that student teachers commonly have difficulty handling disruptions during lessons, recognized that a simulation might help the students bridge the gap between their methods courses and their field experiences. After defining this need, faculty members conducted a search of available simulation software and concluded the *Curry/Strang Teaching Simulation* would best match the research-based methodology taught in the ECU course on classroom management and organization. The simulation was chosen because it incorporates the use of wait time, probing, having students recall rules, "withitness," and even body language in the choices given to the teacher.

Design. Because the *Curry/Strang Simulation* allows the teacher educator to specify lesson content, individual pupil characteristics, misbehavior types and frequencies, and lesson length, we were able to customize the simulation to match our needs.

Development. In the case of IRIS, the main focus was on the development of a new simulation. With the *Curry/Strang Simulation*, the focus was on presetting its training features to meet our instructional needs.

Dissemination. We are currently conducting several evaluative studies of the simulation. One study involves administering the simulation to sophomores in an introductory course, to students about to begin student teaching, to students who are currently engaged in or who have completed student teaching, and to experienced teachers. The profiles of interventions selected will be analyzed to determine whether differences exist between the choices of inexperienced and experienced teachers. In another study we are examining the effects of self-evaluation and debriefing after the first lesson on performance in the second lesson. The results will provide measures of the effectiveness of the simulation and indications of how it can best be utilized within the teacher education classroom. The simulation is also a component in the program evaluation for the ECU Model Clinical Teaching Program (MCTP). Students in MCTP spend an entire academic year in public school classrooms; their choices in the simulation are being compared with those of students in a traditional 10-week student teaching experience. Once evaluated, the simulation will be incorporated into the course on classroom management and organization. It is also being considered for use in alternative certification training programs and inservice workshops.

Planning Lessons Using Simulation (PLUS)

Define. A tutorial/simulation software package, *Planning Lessons Using Simulation* (PLUS), is currently in the definition stage. Lesson planning traditionally involves determining objectives and selecting and sequencing activities. Recent research has shown that effective lesson plans should also include provisions for gaining the attention of students, facilitating practice of learned material and skills, and summarizing the lesson (Rosenshine, 1987).

Instructors frequently find that students have difficulty understanding and applying the lesson planning models taught in methods courses. Plans are underway at ECU to develop a tutorial/simulation software package called *Planning Lessons Using Simulation* (PLUS). The package will allow students in a course on generic teaching models to review and practice lesson planning at their own pace in a concrete-modeled environment before having to plan for instruction in a concrete-real classroom setting during field experiences and student teaching. Because the same lesson plan format is used in all elementary methods classes in the department, instructors in a number of courses will be able to use the tutorial and simulation for instruction or review. The package will also be a valuable resource for the large number of students entering education through alternative means of certification or lateral entry.

Summary

Integrating concrete-modeled experiences in the form of computer simulations into the elementary teacher education curriculum does not occur overnight. In this paper we have noted certain conditions that must exist: need, availability of resources, interested faculty. These conditions exist at ECU and led to the development and use of one simulation, IRIS, to the varied uses of a second, the *Curry/Strang Teaching Simulation*, and to plans for the development of PLUS, a tutorial/simulation to provide students with concrete-modeled experiences in lesson planning. This program of research and development occurred over a period of three years. Over the next three years, we hope to develop additional teacher education simulations and to conduct a number of additional studies.

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Section Editor: Frank Lowney

ISSUES

There is one thing that has puzzled those of us who are keenly interested in technology and teacher education more than anything else. It is the question of why the enormous potential of the computer for education has not been realized more than it has. Even after adjusting for the over-optimism of the "true believers" and the hyperbole of the computer and software industry, there is still a great discrepancy between promise and reality. What have we yet to do to fully unleash this potential? This is the theme that is common to all that has been contributed to this section. I believe that the issues raised here are all very worthy of our attention and, should we attend to them wisely, more of the promise will become reality.

This issues section brings us a wide variety of ideas about training teachers in the use of technology. What are we missing in the software selection process? Have we overlooked some of our most flexible and powerful CAI options? Is there something we can discover about teaching programming from the literature on how a second or third natural language is learned? Are we doing all that we can to assure that the teachers we train can contribute meaningfully to the need for a technologically capable population? Are there personality variables that we should be attending to in order to assure the readiness of our students to learn about technologies that are new to them? Is it reasonable to expect the graphical user interface (GUI) to ease our teacher training tasks in the technology area? What can we learn from observing what teachers actually do with computers and what they say about their own motivations? What should one do to make a $185,000 grant for a networked computer lab pay off in the biggest way possible? These questions will be tackled by an equally varied group of talented teachers, researchers and teacher educators.

More specifically:

Karin Wiburg (Three Schools in which Teachers have Successfully Integrated Technology and Teaching) describes the roles university-based teacher educators played in the successful integration of technology. Success clearly requires more than buying hardware and software and delivering it to the school.

Elizabeth Downs and Kenneth Clark (Meeting the Needs of Students: Learner Characteristics in the Software Selection Process) raise the issue of whether learner interactive variables are being given the appropriate weight in the evaluation of educational software. Using the Dunn and Dunn learning styles model, the authors explore how these learner-centered variables might influence the selection and use of educational software.

Anthony Frisbie (Using Integrated Software as a Courseware Prototyping and Delivery Tool) examines the

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state of Computer Assisted Instruction (CAI) options for classroom teachers. The author illustrates the pros and cons of traditional CAI and several varieties of teacher-produced CAI. Among the latter, the author points out the advantages and disadvantages of authoring systems, hypertext/hypermedia, and template-based courseware development. The use of word processor, database and spreadsheet templates developed with integrated software packages like AppleWorks and Microsoft Works, the author concludes, provide the most accessible, powerful and flexible options for contemporary computer using educators.

Michael Littman (The Impact of Technology on Business/Marketing Teacher Education) describes the example of Business/Marketing Education in New York as an important instance of how teacher education is responding to the need for a population with a high level of technological competence in order that they may survive and prosper in an increasingly technology-oriented workplace.

William Lomerson and Joanne Lambert (The Impact of Technology Learning Readiness on the Integration of Computers Into The Curriculum) put forth the view that teachers as adult learners may or may not have the attributes that constitute "readiness" for learning what they must know and be able to before computers can be integrated into the curricula these teachers are primarily responsible for. Technology learning readiness characteristics are identified and an instrument to detect those characteristics currently under development is described. With instrumentation of this sort one may be able to identify areas that need further development before training in the use of technology will have maximum effect.

Robert Lucking (Windows for Education: Promise or Just Another GUI Mess?) reports on the advent of Graphical User Interfaces in the MS-DOS world and suggests that the real measure of value for educators in these matters is to be indexed by the reduction of time required of both beginning and experienced computer users to learn how to use applications effectively. Thus the author points to a fertile area for research.

Dianne Novak (An Exploration of Computer Use by Beginning Elementary Teachers) reports the results of qualitative research she conducted to ascertain how beginning elementary teachers use computers. Findings of this research provide important suggestions as to how teacher educators and school districts might better facilitate the transition from novice to experienced teacher both generally and with respect to the effective use of computers in the classroom.

Tronie Gunn (A Concurrent Bilingual, Whole Language Approach To Programming Instruction) draws upon research done on (natural language) bilingualism to learning BASIC and Logo concurrently and sequentially. Preservice teachers work with extant parallel programs in both BASIC and Logo. This is analogous to "whole language" instruction in the natural language sense. The object of this ongoing informal research activity has been to determine whether principles that obtain for whole language instruction and bilingualism in natural language instruction are also valid in the case of computer languages.

Larry Reck and Darrell Swarens (An Educational Experiment with IBM at ISU) report on how Indiana State University is using a $185,000 grant from IBM to establish a networked computer lab used by students and faculty of both the campus laboratory school and the School of Education. A key ingredient to success in such an enterprise, they discovered, is to have a full-time lab director who is highly responsive to the needs of all those who use the lab.

The overriding issue here is whether the computer becomes, as Downs and Clark put it, "...an indispensable tool in the educational process or joins earlier technological marvels in the closet.". The kind of thinking represented by the authors cited above is what will make the former more likely than the latter so let's keep up the good work.

Three Schools in which Teachers have Successfully Integrated Technology and Teaching

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The most exciting thing about technology may not be the technology itself but the way its use changes learning environments. A high school teacher uses a bar code reader and videodisc player to show examples of prejudice in *To Kill a Mockingbird* and then asks the students to define "prejudice" and defend their definitions. In an elementary classroom a sixth grader suggests a better way to format the prompted writing software the class has been developing and the teacher implements her suggestion by typing it into the classroom computer which is connected to an overhead so everyone can consider this suggestion. Students in this same elementary room move easily between collaborative working groups, teacher-directed lessons, and individual or paired work at one of the 15 computers located in the middle of their two open classrooms. A high school German class explores different verb endings using a HyperCard stack developed by the teacher and projected on a screen at the front of the room. Student suggestions for grammatically correct sentences are typed in and discussed as they are created.

This is a case study of the introduction of technology as an instructional tool into three school settings, an inner-city elementary school (Bay Park Elementary in the San Diego City School District), a high school district in East San Diego County (Grossmont Union High School District), and a two-school elementary suburban district (Del Mar Elementary District). In all three settings there has been a significant change in the way teachers are teaching, students are learning and school personnel and functions are being organized. Related to these changes are a critical mass of teachers who are successfully integrating technology with their teaching.

None of the schools discussed are specially-funded technology sites. The acquisition of hardware and software as well as most of the staff development was paid for by regular district funds, even though two of the sites are located in low to middle-income areas. These schools, Bay Park Elementary and the Grossmont District serve a diverse group of multi-lingual, mobile students. Del Mar Hills Elementary, located in a small, fairly affluent suburban district, is as much a school as a district since the two elementary schools deliver the same program. This article describes the three sites, the teachers who played leadership roles in implementing technology, and some of the strategies used to introduce teaching with technology. Approaching the study of educational technology by looking more closely at schools which are using it effectively parallels the effective schools research.

The Del Mar Elementary Schools

In the Spring of 1989, two college professors, Dr. Jerry Balzano from U.C.S.D. and myself, were invited by a parent, a sixth grade teacher, Tom Hauser, and a computer-using principal, Jeff Swenerton, to work with 60 sixth graders in an open classroom setting using three new Macintosh computers. We happily spent a couple of mornings a week introducing some of the students and their teachers to the power of word processing to enhance the writing process. During the Spring we wrote and received a small grant focused on creative computing offered during an extended school day. This funding provided two part-time consultant positions for Dr. Balzano and myself during the 1989-90 school year to expand this initial computer-based learning project.

September and October of 1989 were spent introducing the teachers to the use of the Macintosh during open after-school labs. The use of word processing programs and graphics tools to produce instructional materials was stressed. There was genuine excitement about producing spelling lists and flyers and banners began to appear around the school.

In October, a notice was sent home to parents inviting them to sign up their children for an after-school creative computer program staffed by the consultants, the student teachers we had been able to place in the school and some volunteer graduate students in education. Due to the limited number of computers (three!) only six to nine students could attend the sessions at any one time. The next day applications from 75 parents for the after-school program arrived at the elementary school office. The demand far exceeded the supply and parents in this small community immediately put pressure on the school board to get more computers! District priorities were shifted and in a few weeks there were 15 computers in the sixth grade areas of the two elementary school's. The computers were used continuously during the day and after school for word processing, graphics, and HyperCard projects. After the in-school and after-school programs were well underway, we invited 6th grade students to apply to be computer tutors for younger students. The selected tutors, five boys and five girls, introduced all of the fifth graders and most of the fourth graders to computer use before the end of the year.

Today, Spring of 1991, Tom Hauser (the former sixth grade teacher) is now a full-time computer curriculum teacher assisting the staff at both elementary schools in Del Mar to integrate educational computing down through the grades. The two college professors have moved on to support other schools as they begin to implement technology. Last Summer the district provided all teachers with a computer to use during the Summer and delivered two weeks of intensive training through a Summer Computer Institute. Teachers began by creating instructional materials and have slowly moved towards working with students on the computer.

The schools now provide rich access to computers with teacher and student stations scattered among the open classrooms, work rooms and libraries. They are constantly in use. When visiting the school it is sometimes hard to find a specific teacher since she or he might be surrounded by students while demonstrating a program at a computer. Probably the most telling indication of computer integration is the way students answer questions about what they are doing. They say "I'm finishing my poetry packet" or "Completing my social studies stack" not "I'm working on the computer." The next step for Del Mar will involve expanding their curriculum focus from language arts and social studies to science and math and their computer use to include interactive videodisc.

Bay Park Elementary

Bay Park is an example of the transformation of an old, traditional school building into an exciting and stimulating modern learning environment. It is also a poor school in which much of the change has been the result of dynamic leadership and new ideas and organization rather than financial resources. The school of 500 students includes a large number of ethnically diverse students as well as learning and physically handicapped. Tables have been pulled out into the halls to display student work and serve as ongoing activity centers. The warmth of the staff towards each other, the large number of volunteers present and the diverse student body is immediately evident. Student teachers from three local universities are also well integrated into the program.

The school has been actively involved in site-based management since 1986 and successfully petitioned the school district in 1989 to allow them to eliminate grades in social studies and science and concentrate on portfolio assessment of student work. In the Spring of 1989, the school steering committee (five teachers, the principal, an office staff representative, two parents and a parent aide) sponsored a restructuring day for staff, administrators, and community members at which the following goals were developed:

(1) The integration and coordination of curriculum across grade levels and subject areas, utilizing the state frameworks, local school district guidelines, community input, real world experiences, and a variety of methods and media to meet diverse student learning styles;

(2) implementing professional growth activities for all staff relating to these goals with an emphasis on team building;

(3) development and implementation of alternative measures for evaluation of student progress;

(4) utilization of the whole community, including the

student, as a learning resource.

Along with a real commitment by the principal, staff, and community to restructuring, the school had been using technology in a limited way for a long-time and had received one of the early California technology grants designed to support teacher-developed computer use in the classroom. One of the interesting things about this site is that instructional television as well as video are used as heavily in the curriculum as computers.

In the Spring of 1990, a group of teachers met to develop a new coordinated technology use plan which is being implemented this year (Rompala, Hamilton, and Wiburg, 1990). Since the development of student communicative skills is a central school goal the group decided to focus during the first phase of the plan on the use of technology in language arts, concentrating on training staff to integrate technology with methodologies that increase student communication skills. The committee believes teachers are the key to successful integration of technology with school goals. The school technology committee decided on specific outcomes for both staff and students as follows:

Goals for Staff

We believe that once teachers become conversant with technology, they will encourage their students to be creative in its utilization. It becomes critically important for teachers to strengthen their own skills in order to provide more adequate instruction for students. Teachers need assistance in using technology to design more communicative learning environments for language arts. Under-utilization of technology in the past was due to a lack of training and awareness of appropriate technology-based learning and teaching models. Optimal staff development is to be provided by a combination of training workshops, follow-up coaching, and collaborative staff planning and support at the school site.

Staff Outcomes

1. Teachers will demonstrate an ability to use a microcomputer, a VCR, and an overhead projector to enhance their teaching of language arts, both at the end of a staff development workshop and during follow-up lessons and coaching in the classroom.
2. Teachers will identify and generate material in support of the Language Arts curriculum as measured by collaborative files, both on and off the computer.
3. Teachers and classified staff will utilize technology to manage the literature-based curriculum as measured by the development of a school-wide integrated curriculum data base.

Goals for Students

The Language Arts Framework (California, 1987) emphasizes the active construction of comprehension for personal meaning. We agree that students learn best when they are encouraged to construct meaning from real world activity and that technology assists this process by allowing learning in all modalities, (graphic, text, video and sound) and tools that provide for the creation of personally meaningful products.

Student Outcomes

1.1 Students will work collaboratively with teachers and aides to create, expand, and extract information from data bases designed to assist writing and publication.

1.2 Students will improve functional ability in writing by improving their keyboarding skills, as measured by pre and post examination (PAWS).

1.3 Students will learn how to use simple painting programs and desktop publishing programs, as well as HyperCard, to enhance their writing with graphics, sound, and interesting lay-outs.

2. In a collaborative and cooperative atmosphere, students will work together both in the classroom and at the computer to utilize the writing process as part of the literature-based curriculum.
3. Students will self select writing projects for publication (portfolio assessment) that demonstrate an understanding of core literature concepts as they relate to their personal experience.

The Bay Park Technology Committee did receive a small grant in June, 1990 that allowed them to provide substitute time to teachers who are working to facilitate the implementation of these goals and for the purchase of three Macintoshes, a laser printer, and modem. This equipment is located next to the existing Apple II lab and currently provides a "Writing and Publishing Center" for students, staff, and parent volunteers. The center includes expanded telecommunications capability using FrEdMail and Prodigy's on-line encyclopedia.

On a recent visit to the school, I could feel the enthusiasm of the teachers for these new tools, even though many of them are novices. I asked, Pat Rompala, the Special Education Teacher who coordinates the technology committee, what accounts for the shared enthusiasm and taking of responsibility for technology by this staff? Pat replied, "We just keep bringing it up.. at every staff meeting, and related to every issue." She also suggested that she had a strong technology committee with broad representation: a fifth grade teacher with video production background, the instructional assistant for the lab, a fourth grade teacher who was an early user of technology , and a Chapter 1 (Basic Skills) teacher with very little knowledge of technology but lots of enthusiasm for new methods of teaching. In addition, thanks to an AB1470 California Grant, teachers are provided with an afternoon a month for planning, the opportunity to visit other schools that are doing exciting things with technology and the chance to learn new skills by attending workshops and trainings. This support has kept the committee excited. Bob, the teacher responsible for many of the video projects at the school, mentioned that at his previous school he never hear about any staff development opportunities. Here, the principal made sure he knew about all available learning opportunities. An example of the collaborative nature of the school is reflected in a recent decision by this committee to each learn one piece of powerful software well and then teach the others. What a simple and cost-effective approach!

Technology-based cooperative learning activities can be seen throughout the schools. Fifth grade students design and produce videos for other teachers and classrooms. One video on the visually-impaired students at the school using technology was presented recently at a national conference. Pairs of students work together with computers in the back of classrooms and seem able to work without extra help for long periods of time. There is more learning by teachers and teaching by learners, reflecting a remark by a teacher in one of the Apple Classrooms of Tomorrow (ACOT Report, 1991) who suddenly discovered that there were 30 other "teachers" in her classroom and wondered why she had never really used them before.

The activity and display centers that fill the halls of this very old but very inviting school continue to draw the visitor but now showcase a broader variety of products, from hand-made pottery to desktop published newsletters. I was especially pleased by a collection of individual displays from one classroom related to different countries. Side by side on bright yellow posters were paintings, computer-generated charts, cloth flags, art collages, and reports made by a children's publishing program. Diversity in this school is truly a resource.

Grossmont High School

Warren Williams, the computer teacher who was hired to coordinate the implementation of a new technology plan for the Grossmont High School District during the Spring of 1990, was recently described by a local Apple representative as a man full of bullet holes. The goal of the technology committee (a representative group from each school) during the first year was based on a decision that the greatest educational impact for technology was to begin with teachers. Against great resistance and with the help of key supportive administrators, the technology committee convinced the School Board to provide enough money so that teachers who agreed to participate in the project would be provided with a powerful teaching station including a computer (their choice of an IBM or a Macintosh), an overhead and LCD display, a printer, as well as adequate staff development.

The difficulty of the task became readily apparent the first day of Warren's job last Spring, when he had to tell teachers who had written technology grants for a California Bill 1470 not to accept the money, since due to the way funding was allocated this relatively low-income district would actually lose income. He didn't win any popularity contests with teachers who had struggled to write these grants. However, Warren had been a teacher in the district for 16 years and had the support of teachers and administrators who respected his knowledge and experience. Warren also commented his personality might have been helpful. He saw himself as easy-going and low-key as well as someone who never took "no" for an answer. He also brought in the vendors (Apple and IBM) from the beginning of the project and insisted on and got excellent support from them.

The goals for the first year rested on the committee's belief that it was only by turning teachers on to technology that the benefits of technology would reach students. While the district had always been committed to restructuring, had a relatively small and level administrative structure and a long history of site-based management, this first year project was designed to empower a crucial group of teachers from all of the district's eight high schools to integrate technology with teaching. The committee asked each high school to invite teachers to apply for training. These teachers would need to commit to two weeks of training during the summer, attendance at monthly follow-up workshops, participation in the software review and selection process and an interest in using the computer as an interactive chalkboard for instructional presentations in the classroom. In exchange the teachers would be given powerful electronic teaching stations consisting of a computer (an IBM or Macintosh), a printer, overhead projector and LCD display which were theirs to keep as long as they worked for the district. Three hundred teachers applied and 118 were accepted, approximately 15 from each school who were recommended by the site principal for the program.

The two weeks of training provided for both Macintosh and MS-DOS computers included the use of Microsoft Works and either HyperCard or LinkWay for educational applications. I asked Warren, if in retrospect, teaching teachers to use Hypermedia paid off since my experience had involved more success teaching students to use these tools than teachers. These software applications are extremely powerful, but not easy. Warren agreed that using the software at first was difficult, but also said it was the best thing he ever did. Teachers have really developed their skills in this area, so much so, that a recent survey done in HyperCard and sent to each participant came back elaborated by the teachers with all sorts of bells and whistles. Teaching Hypermedia as a classroom presentation tool was also an excellent approach. As a visiting consultant who worked with some of these teachers I was impressed by their expertise and enthusiasm. They dragged their own computers into the training labs at 3:00 in the afternoon after a long and tiring day of teaching, cheered each other on with technical help as well as cookies and snacks and simply didn't leave when the workshop ended at 4:30 or 5:00..They stayed on helping each other to improve their "stacks".

A recent survey found that about 70% of the teachers in the project are using the computer teaching station daily as an interactive chalkboard. The other 30% are still at the word processing stage, developing instructional materials and managing instruction which is in itself an effective use of the technology. However 70% of the teachers is certainly a critical mass to begin to expand teaching strategies to meet more of the learning needs of the district's diverse students.

The district's next step is to provide more student labs. However they, like most California schools this year, have met unusual financial difficulties. In spite of this, they have bought two new labs from categorical funding and believe that the foundations have been laid for the exciting use of technology in the curriculum.

Conclusions and Implications for Educational Practice

Strong Leadership and Strategic Planning

There are a number of commonalities in these schools in spite of the diversity of population, grade level, size, and community resources. All have strong instructional leaders who are responsive to both their staffs and their communities. In two cases the leaders were teachers with strong support from the computer-using principals at their school sites (Bay Park and Del Mar Elementary). The other leader in the Grossmont District was an experienced teacher and newly appointed administrator. The projects were well-planned and intentionally limited with a focus on specific populations, approaches, or curriculum areas. Depth and quality seemed to be more important than breadth. A very well-organized time frame for implementation was also mentioned as a factor in the success of the project by one leader.

Outside Support

All three projects had support from agencies outside of the public schools, either university people and/or business. Del Mar had a small grant that provided university consultants on a continuous part-time basis for a year. In addition student teachers, community and parent volunteers were available to assist with technology projects in both elementary schools. Many of these volunteers were happy to work in exchange for the opportunity to learn about technology. The use of student teachers and their supervising faculty in the projects seems like a win-win situation for both the school sites and the teacher education institutions since few colleges have either the equipment or the expertise to assist student teachers to learn to teach with technology. Vendors, in this case both Apple and IBM, as well as the installing dealers played an important role in the Grossmont District by providing technical support and paying for some of the training.

Teachers First

All of these districts ~~made the~~ decision that teacher training must come first and that only ~~by~~ exciting teachers about the potential of technology to enhance teaching and learning would students receive the best educational effects of using technology. Due to additional funding, Del Mar was able to begin with both teachers and students, at least at one grade level. However, Jeff Swenerton, the principal of Del Mar Hills, suggested that it is the excitement of teachers he is most enthusiastic about. He commented that in his many years as a teacher and administrator he had never seen experienced teachers so excited about a new strategy or tool. This renewed interest in teaching and learning by teachers has increased the focus on **learning** in schools (as opposed to the traditional emphasis on controlling and measuring) and is having a positive impact on student outcomes.

Access to Tools

All of the teachers in all of the sites had rich access to computer equipment, software, and support. Del Mar decided early to provide multiple laser printers, which helped novice users to be pleased with their early attempts at desktop publishing, provided quality instructional materials, and meant the relatively silent printers would not interfere with other classroom activities. The concept of a teaching cart has proven to be very useful for secondary teachers who might have to move their displays from place to place. Bay Park, which spent most of their initial money on teacher inservice and support, still developed a writing lab for the school and placed an additional Macintosh, bought by the PTA, in the teacher lounge for continuous use.

Support for Restructuring

All three school sites have a supportive administration and a school board committed to restructuring, willing to take risks and to shift financial priorities to provide needed equipment and staff development. In all three sites there was a significant and long-term commitment to restructuring which included a heavy buy-in from the parents and community, and support from the school district administration. (Del Mar, San Diego City Schools, and Grossmont Districts have all gone on record as committed to restructuring and have provided school sites with additional financial support in exchange for increased responsibility).

The National Governors Association (McClain-Midkiff, 1991) suggested at their 1990 Conference that restructuring could be defined in terms of increases in the following four areas: 1) the thoughtfulness of the curriculum and instruction provided; 2) site-based authority and decision-making; 3) teachers working together and being rewarded for innovative practice; and 4) the development of alternative assessments as part of accountability. Ironically, the integration of technology with teaching may do as much to meet the goals of restructuring as setting out to restructure directly. These schools sites show a remarkable increase in teachers reflecting about the purposes of teaching, working together, developing materials designed to stimulate classroom thinking, and accepting alternative student products for assessment such as videos and HyperCard reports. The environments exhibit a renewed focus on teaching and learning by all players in the educational enterprise, It is not the technology itself that is so exciting but the fact that its use creates collaborative, exciting new learning environments.

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Meeting the Needs of Students: Learner Characteristics in the Software Selection Process

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A significant increase in the quantity and quality of computer softwar. ıs occurred in the last few years. Numerous articles and books have been written detailing the software evaluation and selection process. For the most part these articles deal with how software fits into the curriculum, how it correlates to the textbooks currently being used, how the program runs, its cost, and hardware requirements. (Schueckler & Shuell, 1989; Duchastel, 1987; Niemeyer, 1986; Perreault, 1986; Wallace & Rose, 1984). These issues are important and need to be evaluated when selecting software. However, as Flouris (1989) has stated, "Each program's effectiveness will depend upon the specific purpose for which it is used as well as on its potential to develop certain capabilities in learners" (p.17).

While there have been articles written concerning software selection and special-education students (Rettig, 1987; Hofmann, 1985; Hummel & Senf, 1985), students-at-risk (Friedman & Kephart, 1989), and gifted students (Bull & Davis, 1988), very little has been written about software selection and the learning characteristics of the "regular" student. The use of computer software should be in the best interest of all children, each of whom may be affected by different software characteristics.

Each child approaches a learning situation from a unique perspective. Each child brings his/her own life experiences and individual characteristics into the classroom setting. There may be enormous differences among all of the learners in a classroom environment. When considering the differences among learners, educators must analyze each learner to identify his/her strengths and weaknesses.

Learning Styles

Differences in learning styles greatly influence each child's ability to learn. In the field of learning style theory, many models exist to explain or identify differences among learners. Various researchers define learning styles differently. However, the Dunn and Dunn Learning Style Inventory provides a meaningful framework for the discussion of computer software selection.

Dunn and Griggs (1988) have defined learning style as "a biologically and developmentally imposed set of characteristics that make the same teaching method wonderful for some and terrible for others" (p. 3). The Dunn and Dunn Learning Style Inventory was designed to identify learning preferences in children. The model consists of five major areas that might influence an individual during the learning process. The five areas or elements are: (a) environmental stimulus, (b) emotional stimulus, (c) sociological stimulus, (d) physical stimulus, and (e) psychological stimulus.

Environmental stimulus describes the conditions of the setting in which the instructional activity is occurring.

Concerns include the amount of light available in the learning environment, the level of noise or quiet in the learning environment, the temperature, and the physical surroundings of the classroom.

Emotional stimulus refers to the attitude characteristics that a learner brings into the environment. These stimuli are part of the learner and influence the manner in which the learner approaches a learning situation. The emotional stimulus category includes motivation, persistence, responsibility, and structure.

Sociological elements describe the grouping patterns learners may prefer as they engage in an instructional activity. As Dunn and Dunn (1978) have described, "Contrary to widespread belief, there is no single way in which to group students for maximum learning. Students learn in a variety of sociological patterns that include working alone, with one or two friends, with a small group or as part of a team, with adults, or, for some, in any variation thereof" (p. 12).

Physical elements include perceptual strengths, intake, time, and mobility. Perceptual strengths refer to auditory, visual, tactual, and kinesthetic senses. The physical element of intake refers to the need exhibited by some learners to eat or drink while working. The time element identifies time preferences for working; people differ in their tendencies to function early in the morning, midmorning, afternoon, late afternoon, and evening. Mobility is the difference among learners in their need to vary their posture or location during learning activities.

Psychological stimulus refers to how individuals process information. Dunn and Griggs (1988) have described these cognitive styles in terms of cerebral dominance, and also include other descriptions or labels of cognitive style such as global or analytical, impulsive or reflective, and inductive or deductive.

Learning Style Elements and Computer Software Variables

Most current software evaluation and review forms stress program characteristics (Schueckler &Sherell, 1989). In a study by the Educational Software Evaluation Consortium in which criteria for judging educational software was rated, program characteristics again come out on top (Bitter & Wighten, 1987). The results of the study indicate that eight of the top 10 criteria relate to the characteristics of the program such as the correctness of content (i.e. is program free from errors in content, computation grammar, spelling, etc.), the ease of use, the correct use of technology, and program reliability (i.e. is program free from errors of any kind). Out of the 22 resulting criteria, the lower ranked criteria included the following learner interactive variables:

- user control
- feedback
- branching.

Although program characteristics are important criteria, learner interactive variables of software may determine the effectiveness of a program in achieving a given objective for a specific learner.

Given the five learning style elements of environmental stimulus, emotional stimulus, sociological stimulus, physical stimulus, and psychological stimulus, there are some critical match-ups to consider in the software selection process and those criteria considered less important in evaluating software.

User control is the ability to control the rate, amount, and sequence of the information being presented in the program. Dunn and Dunn (1978) have stated that students differ in the level of persistence they exhibit when confronted with a learning task. "Just as students in a given group should be assigned different objectives based partially on their ability levels and interests, so should the length and type of assignment for individuals be varied based on your observations of their ability to complete or stay with a task" (Dunn & Dunn, p. 9). The ability to choose the rate, amount, and sequence of information allows students to control instruction to meet their own needs. Weisz and Cameron (19..5) have stated that one of the motivational factors of computers is the aspect of control. When students are in control of the learning, they also have more control of the learning outcomes. The software variable of user control would also have an effect on the amount of structure that faces a learner in a given program. Based on Dunn and Dunn's emotional elements, "Structure limits the number of options that are available to a student and requires an imposed mode of either learning, responding, or demonstrating achievement" (p. 11). While some children would require a high level of structure within a program, other children would feel frustrated and unstimulated by a high level of structure. Therefore, it is necessary to provide user control as an option to choosing the level of structure that exists within a program. Those learners that prefer to work with unlimited confines will thrive when presented with options; those learners however, that prefer structure will not be comfortable without well-defined procedures.

Feedback provides learners the opportunity to assess their progress during the instructional task. This aspect of learning may vary from student to student, again based on their individual needs for structure within the learning process. Students that require a high level of structure would need a continuous level of feedback to determine their current success within an instructional task. Feedback would need to provide a structure to help these students identify the sequence of events required in an instructional activity. For other students, feedback would not be as relevant. Some students may require minimal feedback and would become frustrated by a program that is continually interrupted for the purposes of providing feedback. Additionally, learners differ in their degree of persistence to a task. Persistence identifies the level of commitment learners bring into a learning activity. Some learners bring a high level of persistence into the learning environment. When faced with an instructional task, these children will continue until the task is finished. They will seek help from classmates and other resources to accomplish the assignment. Dunn and Dunn have identified contrasts to the persistent student, "Other students, often those who we say have short attention spans, cannot continue their work for any length of time. The moment these youngsters experience any difficulty they lose interest, become irritated, begin to daydream, or become involved in social activities rather than complete their tasks" (p. 9). For students lacking in persistence, feedback would need to include positive messages and prompts. In addition to the emotional element of persistence, feedback would be an important variable to the element of responsibility. Students who lack responsibility tend to become easily discouraged. For these students, Dunn and Dunn have suggested "frequent encouragement and supervision, and much praise as each objective is completed" (p. 10). Feedback can also influence motivation. When an instructional task includes positive and relevant feedback about the student's performance, it increases intrinsic motivation (Ryan, Connell, & Deci, 1985).

Branching within a program can provide individualized instruction in order to meet the needs of varying learners. Dunn and Dunn (1978) have stated, "It is important to remember that a student who is not motivated to learn in a fairly conventional setting may become extremely interested in achieving in an individualized program" (p.9). These learners may be motivated to learn responsibly when given opportunities to make choices about their learning and to learn based on their learning style preferences. In addition to the emotional element of motivation, branching can accommodate the learning style of responsibility. Branching affords the opportunity for learners to meet their individual needs within the design of a program. Dunn and Dunn have stated that learners with a high degree of responsibility may require a clearly stated task, resources to complete the task, a suggested time frame, a means of gaining assistance if they experience difficulty with the task, evaluation and feedback, and alternative methods for achieving the identified objectives. Branching can work to allow students to connect with instructional styles that match their own characteristics. In addition, through branching strategies, learners are free to explore a content area to the depth and extent that they need.

Conclusion

What constitutes good educational software? There are numerous criteria that can be applied to choosing specific types of software. There are a number of characteristics that can be applied to any software package. Their presence does not guarantee that a program will be good or will suit the needs of the classroom, nor does the absence of one or two of the characteristics mean that the program is not worth investigating and using. The purpose of instructional software is to help students learn new material. The quality of a piece of software should not be judged in an absolute fashion. A piece of software might be extremely useful for one individual and a complete failure for another. The most important aspect of choosing software is to assess the needs of the classroom: What are students expected to learn? Which programs best help teach those skills? Who are the learners? What characteristics do they bring to the learning environment?

Despite all efforts to streamline the process, courseware evaluation, if done properly, will always be a time consuming task. However, if the computer is to live up to its potential as an aid to learning, this task cannot be ignored or minimized. The quality of materials and curriculum fit will determine whether the computer assumes its potential as an indispensable tool in the educational process or joins earlier technological marvels in the closet.

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Using Integrated Software as a Courseware Prototyping and Delivery Tool

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The last 10 years has seen an explosive increase in the number and use of computers in educational environments ranging from kindergarten through university levels. A common problem associated with this increase is that of acquiring quality Computer-Assisted Instruction (CAI) software that meets both student and teacher needs. There are a number of ways software for instructional purposes can be obtained. Probably the most common method is simply purchasing the needed item. The second most common method of procuring instructional software is through "do it yourself", teacher-produced materials, using either standard programming languages, an authoring language or system, or some other method.

An Office of Technology Assessment (OTA) report, completed in late 1988, reported that: 1) there are over 10,000 commercially published, stand-alone educational programs from approximately 900 publishers. 2) Of the 900 software publishers, the top 25 account for nearly 65% of educational sales. 3) A single-disk program from one of these publishers costs $50 or less, with such purchases accounting for approximately 12% of all school expenditures on educational materials. 4) The majority of today's CAI programs fall into the category of drill and practice or tutorials (approximately 65-70%), and do not address higher order thinking skills (Scrogan, 1988; Scrogan, 1989; Sivin & Bialo, 1988). These numbers can be daunting when reviewing materials for software selection.

There are a number of difficulties that can face the potential software purchaser in addition to the volume of material. New commercial software can have a lengthy development time associated with it, often as long as two years (Bruder & Chafin, 1989). This has two effects: first, the software can be obsolete as soon as it is released due to advancements in computer technology and, second, lengthy development time predicates that most products released will address subject matter for which there is a high demand to assure commercial success (Sivin & Bialo, 1988). As a result, many products, while of generally acceptable quality, may be too generic to meet specific course requirements. Others are of poor quality or are inappropriate to the designated audience. Still others are simply inapplicable to many instructional situations. In addition, few commercially available materials allow the teacher to customize the information presented or the sequence of presentation. This is not conducive to the incorporation of software into the curriculum. As one educator put it "... anything but good CAI is worse than no CAI" (Scanland & Slattery, 1983).

The difficulty in locating high quality, relevant instructional software can occasionally inspire teachers to attempt to produce their own software. Teacher produced software has several benefits over commercial materials.

- Information and presentation styles can be altered to meet specific needs.
- Products can be shared without fear of copyright violation.
- Materials can be designed to specifically match curricular requirements.
- Information can be presented in such a way as to match the instructor's style of teaching.

There are, however, some disadvantages to teacher-produced software using traditional programming or authoring tools. One major problem is the amount of time necessary to learn a programming language such as BASIC or PASCAL, even at rudimentary levels. Mastering a programming language can take much longer, even though introductory and advanced programming courses may be taught in inservice workshops (Coburn, Kelman, Roberts, Snyder, Watt, & Weiner, 1982). Few full-time teachers develop these programming skills. Those who do find it difficult to allocate the time needed to produce and debug high quality instructional and CAI materials. This has been estimated by some to be as much as one hour of development time for each minute of instruction (Bullough & Beatty, 1987; Coburn, et al., 1982; Hodges, 1985).

Another avenue for teacher-produced instructional software lies in the use of authoring systems or languages. An authoring language, such as PILOT, is a computer language in the same sense that BASIC and PASCAL are computer languages, i.e., giving the user control of the computer (Hodges, 1985). Unfortunately, there is much the same liability with authoring languages, as regards the time invested in gaining proficiency, as that posed by other high level languages. Also, authoring languages do not have the same flexibility as standard programming languages. Programs written with an authoring language will often execute more slowly than similar programs written in BASIC or Pascal.

Authoring systems, such as McGraw-Hill's *Interactive Authoring System* or the *Guide 2* system from Owl, allow the teacher to produce courseware through a step-by-step, often menu-driven process (Hodges, 1985; Vockell & Schwartz, 1988). There is no "language" to be learned with an authoring system, but rather a set of system-prompted commands. In general, authoring systems tend to be easier to learn but less flexible and less powerful than authoring languages, and far less powerful than standard programming languages (Hodges, 1985). If the options available in an authoring system do not meet the needs of the software designer, there is little recourse.

Hypertext-based systems such as *HyperCard* for the Apple Macintosh, *Toolbook* for MS-DOS machines, and *Tutor Tech*, *HyperStudio*, and *Nexus* for the various Apple II models, all present another approach to teacher-designed software. Hypermedia, as the product of these development tools is sometimes called, offers the designer a wide range of capabilities including incorporating video and sound (Myers & Lamb, 1990; Hypercard Users Guide, 1987). The primary disadvantage with these development tools is one of systems and performance. The requirements of memory, system speed, or additional hardware to effectively work in the hypertext environment, can often put the designer to some expense. There is also a potential problem of instructional delivery if the machine on which software is developed does not match the performance or hardware characteristics of the computers used by the students. So, while these software development systems have great possibilities, their time may not have arrived.

Template-Based CAI

Using software that is normally thought of as "tool" software presents some interesting potential as another method of instructional software design. Using a single application program such as a database, spreadsheet, or word processor, many types of lessons can be designed. Database programs in conjunction with pre-prepared data files can be used to develop instructional activities that perfectly match the teacher's needs (Olds, 1986; Parker, 1988). If students are required to investigate topics for entry into database form, valuable research skills are developed.

When teaching mathematics or business oriented activities, the spreadsheet as a dynamic calculation and "what if" tool is invaluable (Bork, 1985). A spreadsheet enables students to not only seek solutions to mathematically-based problems but to learn the process of formulating such problems themselves. Gaining this type of analytical ability is the essence of mathematic skill. The computer and a spreadsheet program present an excellent opportunity to teach the processes and methods of mathematical modeling (Choate, 1986; Dyrli, 1986; Parker, 1988).

Text-based activities such as creative writing and outlining are well served with a word processor. More than being a tool for putting words on paper, the word processing program gives the user extensive control over text. Using the word processor creatively, the teacher can create both specialized writing and reading assignments as well as provide the logical structure needed to learn effective outlining and composition skills (Parker, 1988; Wolf & Walters, 1986).

There are many ways that standard computer applications may be applied to instruction, the only limitation being the teacher's creativity and imagination. A similar solution to the problem of software development lies in integrated software packages that combine word processing, database, and spreadsheet capabilities, and in some cases, business graphics and telecommunications, in a single program. Products such as *AppleWorks* and *AppleWorks GS* for the Apple II series, *Microsoft Works* for both MS-DOS machines and Macintosh fall in this product category. Conceptually, these products control all of the contained applications from within a single set of commands. The commands may perform different actions depending on which application is currently in use, but the concept of the command remains the same. These programs can easily be adapted to perform the functions of instructional design and delivery, in a fashion similar to single function application programs (Heimler, Cunningham, & Nevard, 1987).

The strength of integrated productivity programs comes from features that are unique to an integrated software environment (Apple Computer, 1986; Van Buren, 1986). Key elements of this environment are:

- Ease of use through an easily mastered user interface
- Moderately powerful word processing, database, spreadsheet and other capabilities
- Command sequences common to all of the applications
- Third-party manufacturer support in the form of text-based materials and accessory software products
- Wide availability and a large user base
- Easy modification of self-produced or commercial template materials
- The ability to produce, edit, move, copy, and print information of different types from within a single program.
- The ability to have several files of each type (word processor, database, spreadsheet, etc.) active at one time.
- The ability to "cut and paste" information from one application to another.
- The availability of context-sensitive help screens
- The ability to create, store, and reuse "template" documents, thus allowing the user to operate in a "fill in the blanks" environment.
- A good platform for quickly testing CAI development concepts in a rough draft form

One item utilizing these features for instruction is a template-based *AppleWorks* data file and documentation package called *Immigrant*, released by the Education Technology Center at Harvard. This CAI program is a study of the utility of an integrated software approach to teaching social studies. The package uses *AppleWorks* data files to generate a simulation of the lives of immigrant families in the US in the 1800s (ETC, 1985; Olds, 1986).

The *Immigrant* package provides information about several immigrant families of different financial means and social station. The user takes this data from a database file and, using additional information from different database files, selects employment, living accommodations, and allocation of income for his/her "family" through a ten year period. Spreadsheet files are used to determine if the choices the user has made are workable within the means and abilities of the adopted "family." The word processor is then used to keep a diary of the events that occur to the adopted "family" (Hoelscher,1988; Olds, 1986).

The appeal of *Immigrant* comes from several factors. Information included in the package can be changed at any time to meet specific curricular needs. It involves the students, allowing them to identify with the characters in the program and gain more insightful knowledge. Use of the word processor gives the student a valuable creative writing experience, organizes the information the student has gathered and encourages hypothesis generation. In use, the program covers a broad range of knowledge domains and skill areas, and is well suited to integrating the computer into the curriculum at a number of different levels (Goldie; 1988; Szymona; 1988).

Using the *Immigrant* package as an example of what can be done within the environment of an integrated software package, certain generalizations can be made: First, the package is effective CAI (Hoelscher, 1988). Second, its effectiveness depends not so much on the software and content materials, as it does on the quality of both teacher and student involvement (Hoelscher, 1988; Szymona, 1988). Third, it demonstrates what can be done when common computer tools are used in a new way (Olds, 1986; Hoelscher, 1988). Fourth, people who have learned to use an integrated package such as *AppleWorks* or *Microsoft Works* can design their own courseware using a method similar to that used in the *Immigrant* package (Parker, 1988). Data files developed in one of these packages can be easily moved to and implemented in another, using the same general concepts of lesson design (Kennedy, 1988).

Materials designed using integrated software have some advantages over either commercial materials or teacher-produced software using traditional methods. Among these advantages are (Frisbie, 1989):

- Screen formatting for text is simplified since layout and formatting commands are available from within the program. Information can be displayed in different ways depending on the need and the application being used.
- Courseware designed in this environment is self-documenting since word processor, database, and spreadsheet files can be printed easily.
- The easy admixture of word processor screens (for instructions and information), database files (for an information resource), and spreadsheet data (for

calculations or "what if" projections) give the designer considerable control over the progress and direction of a template-based lesson.

- Template-based materials can be easily customized to match course content.
- Template-based lesson materials using integrated software as the instructional platform are multipurpose. While students are learning content material on a particular subject, they are also becoming "computer literate" in the use of a relatively sophisticated application package.
- Integrated software packages are well established in education and are already being used as support software for many types of instruction.
- The tools available in integrated software packages can make it a simple matter for any teacher who is familiar with one of these packages to quickly produce custom designed, modifiable instructional software.

These capabilities provide a broad latitude for instructional design and development. When coupled with the ability to create "macro" keys, the concept of "programming" within the integrated environment begins to flourish. A "macro" is a set of instructions within a program that are linked to a single key stroke. An example of this might be executing a PRINT command from within *Microsoft Works*. Normally, this would entail selecting the FILE menu, selecting the PRINT command, and confirming the PRINT command. The *MS-Key* and *Macro Maker* programs, for earlier MS-DOS and Macintosh versions of *Microsoft Works*, permit all of these keystrokes and commands to be combined into a single, designer-selected keypress, automating the entire sequence. Newer versions of *Microsoft Works* (revision 2.x) for Macintosh and MS-DOS machines have included macro capability as an integral part of the program. For the Apple II line, products such as *UltraMacros* (from Beagle Bros.) incorporate this capability into *AppleWorks*. With these programs, several macros can be saved in a file that can be activated automatically when the program is started. Other macro files can be activated by the user whenever needed by the template lesson. The most significant advantage this added ability has is that while the designer still needs to be knowledgeable about the functioning of whichever "Works" program is used, the user of the lesson need know nothing more than how to begin the program and follow a simple set of instructions about macro keys use. Macros can automate the entire function of the lesson, including loading data files and providing feedback to the user. Macros provide the template-based courseware designer an efficient method of producing instructional materials for those unskilled in computer and program operation. The ability to direct learner activities within the program's scope, provides the type of control available in more complex and sophisticated working environments, but with less expense and greater ease.

Sources of Information and Course Material

For those interested in designing and implementing CAI software in this environment, computer magazines are good sources of ideas and information. Recent articles have dealt with the use of the various "Works" programs as both educational management aids and as instructional tools. Some have specific word processor, database, and spreadsheet templates as a part of the articles. Ruth Witkin, who has recently published a user's guide to *Microsoft Works* for MS-DOS systems, has a column on *AppleWorks* spreadsheet applications in *A+/InCider*. Though these articles are written for Apple users, the concepts and template designs are just as applicable on the *Microsoft Works* programs for MS-DOS machines and the Macintosh. There are several books currently available that also contain template materials for complex database and spreadsheet operations. One of these, *AppleWorks Applications* by Lauren and Robert Flast, has specific examples of 25 different projects covering topics from designing a student database to creating a sales commission register. Other books available, such as *Run! 41 Ready-To-Use Lotus 1-2-3 Models* and *Macintosh Spreadsheets* also by Lauren and Robert Flast, contain similar materials for *Microsoft Works* or programs compatible with *Microsoft Works*.

Microsoft supports the educational applications of its product through a quarterly publication, *The Works Education Newsletter*. This publication covers a wide range of educational products including sources of template materials and accessory programs compatible with *Microsoft Works*. The newsletter also contains names of educators using this product as instructional support software and a tips and tricks section (*The Works Education Newsletter*, 1988).

There are several computer literacy textbook/workbook combinations using *AppleWorks* or *Microsoft Works* as the baseline program for teaching word processing, database management concepts, and spreadsheet. Some of these titles are: *AppleWorks In The Classroom Today* by Gary Bitter (Mitchell Publishing), *Using AppleWorks, With An Introduction To BASIC* by Keiko Pitter (Mitchell Publishing), *Tools For Schools: Applications Software For the Classroom* by Sandra Turner and Michael Land (Wadsworth Publishing), and *An Introduction To Computers Using Microsoft Works* (Lawrenceville Press). Each contains text versions of word processor, database and spreadsheet activity files that are duplicated on enclosed or separately available floppy disks.

Among the commercial items available is *NewsWorks*, from *NewsWeek* magazine, which is a regularly updated current events *AppleWorks* database disk and educational support materials. Another example is the four volume *FactWorks* series. Each volume is a single disk with *AppleWorks* data files on both sides and a small, but informative, manual. The files on these disks cover a range of topics from science and the space program to sports and geography. Heizer Software provides many template offerings through the company's regularly updated catalog and supports both the MS-DOS and Macintosh versions of *Microsoft Works*. Microsoft itself offers an educational support product called *WorksBox*. Also available from Microsoft are student workbooks and a site license to accompany the *WorksBox* kit.

Public domain and "shareware" template materials are also available. Advertisements in many computer magazines offer disks of template materials on specialized subjects. Another good source for these materials is through local computer clubs, computer bulletin boards, and special interest groups. One group that specializes in *AppleWorks* template items specifically designed for teachers is the Teachers' Idea and Information Exchange (TI & IE). This group is centered in Nebraska, and sells single disks, with information recorded on both sides, for about $6 each. A one year subscription to TI & IE, ten to twelve disks, can be purchased for about $50.

Conclusion

Template-based, microcomputer implemented instructional software, using integrated software such as AppleWorks or Microsoft Works, is neither a substitute for commercial materials, nor is it a substitute for non-computer oriented pedagogy. This technique does, however, empower teachers with a means of producing and delivering instructional materials that fit both their needs and particular teaching styles, and their students' needs when other methods are inadequate or unavailable. A database file, word processing document, and spreadsheet template are static items. It takes creative thinking and imaginative implementation to bring dry information to life. These are the skills the teacher brings to the lesson (Daver, 1988; Olds, 1986, Parker, 1988).

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The Impact of Technology on Business/Marketing Teacher Education

Michael J. Littman

Background

Computers can enhance instruction, motivate students, and prepare students with necessary business skills. In business/marketing education courses today, technology has opened new opportunities to bring real world experiences into the classroom. Concomitantly, this has translated into a demand for teacher education programs that better prepare Preservice teachers with the necessary skills to teach newly revised courses that many states, including New York, have added to their business education curriculum.

According to the Introduction of the curriculum guide for Business Analysis/Business Computer Applications (New York, 1988), "Nearly all jobs will soon require workers to know how to process data and/or use information systems. Thus, in its new role, business/marketing education calls for the development of a balanced program that will enable students to acquire a broad understanding of the configuration and operation of various information systems."

New York's key secondary course, Business Computer Applications, provides students with a hands-on-opportunity to explore some of the modern computer software productivity tools used in business. During this course students become familiar with data manipulation through the use of word processing, data base, spreadsheet, and graphics applications. The use of these skills will acquaint students with the interrelationships between and among information, software, business activities, and business systems.

Zahn (1981) stated that business educators must be able to apply computer technology and provide computer preparation to students in their classrooms. According to Titen (1983) existing programs in marketing education must expand to include microcomputer competencies that will equip students to function in today's world. Searle (1986) concluded from a national study of marketing educators that enhanced Preservice and in-service computer opportunities were necessary for secondary marketing instructors.

Model of Business/Marketing Teacher Education

The increased demand for graduates skilled in understanding, using, and applying technology to their courses has led to a revision in teacher education curricula. Many universities and colleges have reviewed their course offerings and have devoted more contact time to technology's impact on society, workers, and students. Since in New York, all students must be prepared to teach with a "technology orientation", we, at State University College at Buffalo, have up-dated and revised our courses to better prepare students to understand and use technology in their teaching career.

Most business/marketing classes offered in New York included an infusion of technology concepts and applications. Major business/marketing courses taught in New York that required technology skills included Keyboarding I, II, III, Electronic Information Processing, Advanced Electronic Information Processing, and Financial Information Processing. Courses that have limited computer application included Accounting and Principles of Marketing. Since teachers must be prepared to teach these courses, they need to be fully prepared through their teacher education program to be knowledgeable, competent, and confident in computer usage.

Littman (1990) concluded that business/marketing education students considered themselves as more knowledgeable, as more competent, and as more confident in the use of microcomputers than other students. Business/Marketing education students had the highest level of agreement that microcomputer usage in courses was more likely to lead to written communication skill enhancement. They disagreed that microcomputers made courses more difficult, added more work, or made courses more difficult.

Business/marketing education students were less apprehensive about using microcomputers in their courses than business or non-business students. Business/Marketing education students reported the highest levels of agreement that microcomputer literacy was important to career success.

Business/marketing education students had the highest level of agreement that more courses should require microcomputer usage. Increased course usage of microcomputers should lead to enhanced skills and better professional preparation necessary for effectively teaching business/marketing courses in New York secondary curriculum.

Conclusions

The strategies most important to business/marketing education were:

What:

1. Stress the importance of technology, its components, and computer usage in business.
2. Emphasize computer usage and skills in word processing, data base, spreadsheet, and graphics.
3. Develop the ability to understand, utilize, and teach new technology.
4. Develop an appreciation for positive changes of technology on instruction.

Why:

1. Meet teacher education goal to prepare Preservice teachers to be knowledgeable, competent, and confident using computers and other technology.
2. Importance of increased emphasis on technology and computer usage in business.
3. Importance of gaining and enhancing computer skills to teach to their own students.
4. Meet society's need for students skilled in technology application, usage, and issues.

Who/Where:

1. Taught as separate course in Business/Marketing Education
2. Taught as separate course in Business Department or other related department such as CIS, Technology, or Education.
3. Infused in all teacher education courses with emphasis on technology, its importance, and especially computer usage and applications.

How:

Skills are infused into the teacher education curriculum in the areas of business simulation, record keeping, data base, computer graphics, and problem solving. Separate courses are set up in Business, Computer Information Systems, and Education for additional emphasis and skill development. These revisions have led to a better prepared and more knowledgeable business/marketing teacher of technology in New York's secondary schools.

In summary, business marketing teacher education has been influenced by technology and the realities of current teacher and student preparation to instill knowledge and application of new technologies, and especially microcomputer usage, in their programs.

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The Impact of Technology Learning Readiness on the Integration of Computers into the Curriculum

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Introduction

In an environment traditionally resistant to change, mandates for technological training are fostering changes in the nation's educational system at a rate unequaled in recent history. Teachers in the public schools, already feeling overwhelmed with societal missions and institutional directives, are expected to learn to use this new technology and to integrate it into the curriculum.

Staff development, preservice training, and inservice training in technology for teachers is a widespread occurrence throughout the educational world, even in school systems not abundantly supplied with computers or other types of technology. While there is evidence that some teachers are using new technology effectively in the classroom, in many classrooms computers can be found just gathering dust, collecting coats, or entertaining students.

Staff development training in the effective use of technology must be made more purposeful for teachers. District funds and teachers' time must be better spent. Analysis of teacher competencies can improve the efficiency of teacher training.

Despite the presence of computers in almost every school system in the nation and a proliferation of inservice training programs on computer application in the curriculum, the Office of Technology Assessment (OTA) in its September 1988 report Power On! states that only half of the Nation's teachers confess to ever having used computers at all. The vast majority of teachers have had almost no training at all in how to apply computers in teaching. This report also noted that "Most teachers want to use technology, but few have found ways to exploit its full potential;" unless teachers are trained in the use of technology and provided goals for new applications, it will not be used well (p.114).

This paper identifies the essential elements, and develops a procedure, for facilitating the integration of computers into the curriculum.

Teacher Concerns

Excuses and explanations abound regarding computer use and non-use by teachers. Administrators and other educational leaders plea for additional funds to purchase more equipment or to offer more training, assuming that increased availability of, or familiarity with equipment will ensure integration into the classroom.

Many studies identify the teacher as the key to implementation of change, and insist that the teacher's attitudes and teaching style will determine whether or not technology will be utilized (OTA, September 1988; Sizer, 1984; Howie, 1989; Adams, 1985; ISTE, 1990). A review of the research on teacher concerns and of current efforts to address those concerns provides a basis for new methodologies which characterize types and levels of technological training that will best serve teachers.

Reasons most often offered by teachers for their failure to implement computers and other technology in the classroom are lack of available hardware, lack of training, and lack of time to plan for use (Becker, 1985). There is also evidence that many teachers overcome both practical and intellectual barriers to successfully integrate computers into the classroom environment (OTA, September 1988; Solomon, 1990). These contradictory situations suggest that an understanding of teacher attitudes, capabilities, and personality characteristics can assist in planning technology training programs which will improve the likelihood of successful technology use.

Wedman (1986) notes that most inservice activities focus on increasing teacher technological expertise rather than addressing their attitudes towards the technology. In two studies using the Concerns Based Adoption Model (CBAM), Wedman found that teachers did not progress through the innovation adoption stages as expected. He concluded that different uses of computer technology elicit different concerns about the innovation.

Cicchelli and Baecher (1987), based upon a two-year study of inservice training on computer literacy, created a staff development model which addressed teachers' concerns about computers. They used an adapted version of the Levels of Use model from CBAM and identified the reactions of users and nonusers to computer use.

In a study (Mitchelll, 1988) using the Level of Use of an Innovation interview, a component of the CBAM, and the Portland Achievement Levels Test, assessed adoption of computers for four areas of instructional management. She concluded that personality traits are probably a factor in movement of individuals to higher levels of use.

Howie (1990) incorporates the Level of Use of an Innovation model in educational settings as a guide for inservice training for teachers. She suggests that educational administrators should attempt to recognize the seven stages of concern (awareness, informational, personal, management, consequence, collaboration, refocusing) in teachers and staff in order to assist them in growing through each concern level. She recommends use of attitude inventories, questionnaires, and personal interviews in order to accomplish this task.

The Stages of Concern Questionnaire, used by many researchers to assess the level of acceptance of computers by teachers, presupposes that all teachers are interested and eager to learn how to use computers. It is further assumed that the identification of the teacher's level of concern about computers will identify the type and level of training required to assure successful implementation of technology.

In an exploration of teachers' concerns over computers in the classroom, Heywood and Norman (1988) studied teachers who had been using computers for less than a year. Classifying them as users, under-users, and non-users, they recorded the teachers' views and experiences on computer use. They concluded that the primary cause of concern and resistance to computer use can be attributed to the teacher's lack of confidence and competence, and not to lack of time and access to equipment.

Implementation of Technology

There are teachers among every training group, and some who are even self-trained, who overcome all barriers of time and money in adapting computers and other technologies for their classrooms. The large majority, however, hold back, apparently in need of additional training in the use of technology. A look at the literature reveals patterns for this occurrence, and lends support to the proposition that repetitive training of the same type is not the answer.

Rogers and Shoemaker, quoted in Houle (1980), characterized five categories of professionals with regard to implementation of an innovation. These five adopter categories, in terms of speed of adoption of an innovation, follow a natural bell curve, and are characterized as follows:

- innovators - willing to accept risks
- early adopters - wait until it is tested
- early majority - wait until peers adopt it
- late majority - adopt only after overwhelming pressure from peers
- laggards - adopt only under duress

These groupings appear applicable to teachers and their acceptance of technology. This suggests that the major portion of the portion of the teacher population is probably resistant to technology training.

Investigations by Evans (1967) support the Rogers and Shoemaker view that the adoption of an innovation is determined more by the way it is perceived by potential adopters than by its actual benefits or characteristics. He quotes Miles, who observes that innovations are more likely to be adopted if they can be added to an existing program without major disturbance to other parts of it. Yet some rebuilding and restructuring of the educational environment must occur if technology is to become one of its integral components.

National statistics indicate that teachers espouse a positive attitude toward computer use in schools and signify interest in taking courses to learn how to use computers for instruction. Data from these same surveys, however, reveal that less than one-third of recent teacher education graduates consider themselves prepared to teach with computers and only 70 to 75 per cent of these feel ready to develop curriculum and use materials properly (OTA, September 1988).

A 1985 national survey investigating instructional use of computers found that about one-fourth of all teachers in U. S. schools reported "regularly" using computers (OTA, September 1988). Further analysis revealed that among those that used technology, the major use in the elementary schools was for drill and practice and tutorials, while in most high schools the major use was for teaching programming or computer literacy.

Subsequent surveys continue to show high teacher interest in learning to use computers and strong support from the states in mandating training, but the integration of computers into the traditional curriculum is occurring at an extremely slow pace (Howie, 1989).

Teacher Characteristics and Readiness to Learn

A review of the literature indicates that successful technology training requires the presence of identifiable personality characteristics. Distinguishing these traits is the basis for the authors' development of a scale designed to assess readiness to learn technology and to suggest training areas for those that are not ready.

Chen and Brovey (1985) noted that teachers and others responsible for making curriculum decisions must be ready to cope with transition from a rigid format to a flexible one with regard to implementing technology in the curriculum. They also recognized the need to develop readiness for using technology, which they addressed by teaching about the technology.

Gall and Renchler, cited in Moursund (Ch. 1.4, p. 5), identified the need for readiness activities prior to training in order to raise teacher awareness of the importance of inservice programs. They further stated that characteristics of teachers as adult learners should be considered in planning teacher training. Dettmer (1986) promotes incorporating the adult learning principles of self-directedness and independence in planning inservice training.

The proposal that self-directed learning should be studied as it relates to the learner's personality characteristics is offered by Oddi (1987). Schleiderer (1979) suggests that the view of self-directed learning as an instructional process should also consider the whole-person approach to learning.

Brookfield (1990) specifies seventeen theses of effective teaching which are appropriate for consideration in preparing inservice training for teachers. Although these principles are addressed to the college teachers, they can be generalized to teachers at every educational level. He emphasizes that taking risks in trying new ideas and self recognition of personality characteristics are essential to good teaching.

In a report prepared for educational decision makers by The International Society For Technology in Education (ISTE) (1990), studies reviewed by Bialo and Sivin are cited with reference to the teacher's role in use of educational technology. They emphasized the need for teachers who are flexible, inquisitive, managerial, and able to fulfill many roles. (ISTE, p.10).

Pogrow (1988), in discussing the ways that computers can improve the quality of education, contends that teachers should be proficient in the latest non-computer techniques of teaching in the curriculum area for which the computer is used. He further states that only a small percentage of teachers are master practitioners who have the capability of converting computer use into learning, and that a link must be built between computer use and improvement of general instruction.

Scardamalia and Bereiter (1989) address the issue of good and bad teaching by characterizing differences between expert and inexpert teachers. They depict expertise in teaching as progressing through three stages of development:

- the survival stage, in which the major concern is management
- the mastery stage, with primary focus on performance and improvement
- the impact stage, when attention shifts from teaching performance to teaching effect on students.

They suggest that a large portion of teachers are at the survival level, which severely impacts their ability to adopt progressive attitudes towards innovative educational approaches.

The OTA report, Technology and the American Economic Transition (1988, May), in addressing the learning process, notes that the results of research on advanced computer designs are likely to influence some changes in teaching strategies. The report further stresses the need for a new set of job skills for the age of technology, which should include the following abilities:

- to recover from mistakes
- to ask for assistance
- to tolerate ambiguity
- to work with insufficient and/or excessive information
- to collaborate in problem-solving
- to identify sources of information
- to penetrate poor documentation

The ability to discern teacher personality characteristics, teaching and learning style, and predisposition to adoption of innovations, should be helpful to planners of inservice and preservice training in use of computers and other technology, and should assist in making predictions regarding the likelihood that an individual teacher would implement technology in the curriculum.

Technology Learning Readiness

The literature reflects a need for determining the existence of specific personality characteristics prior to teacher training in technology. Readiness for learning and using information technology requires different skills and attributes than is needed for traditional teacher inservice education, and the recognition of the presence of these characteristics can be of assistance in preparing teachers for training.

Hiblar and Newman (1983), based upon an analysis of eleven case studies of program initiation in Washington state, prepared a checklist for decision-making on various aspects of educational computing programs. Among the considerations are assessing teacher readiness and inservice planning.

Blease and Cohen (1990), after examining results of research on technological innovation in elementary schools, observe that many researchers support more training in technological applications for the curriculum. The authors maintain that reluctance to take risks is generally characteristic of teacher behavior. Blease and Cohen contend that the basic need is for a change in the teacher's conception of the "teaching/learning process and of his/her pedagogic role within it."

OTA (September 1988), in an analysis of teachers' use of technology, advocates an environment in which teachers can explore and experiment with applications. OTA also supports flexibility in use with teachers allowed to develop their own personal approaches to teaching with computers. The report further states: "Inservice training in technology has unique requirements that distinguish it from traditional inservice activities." (p. 18).

After examining the effects of computers on educational change, Adams (1985) declared that the teacher is the critical element which determines successful and proper implementation of any new idea in the classroom. He asserted that the attitudes of teachers in the learning environment is more important than the programs or educational structures, and cited conservatism of teachers as a major roadblock to acceptance of new teaching tools and techniques. Adams proposed a shift in the approach to training for teachers, removing mandates from above in the organization and allowing teachers to assume responsibility for personal change. He referred to the literature on cognitive dissonance as lending support to the importance of self direction in initiating attitude change (p. 39).

A review of the literature of Conceptual Systems Theory and Concerns Based Development by the ASCD 1981 Yearbook Committee emphasizes the importance of presenting staff development programs that are responsive to the personal/professional development of the teacher. The report indicates that the differences in degree of self-directedness and ability to deal with other conceptual problems are often related to developmental stages, and they review teacher motivation in terms of "professional age." They categorize these ages as beginning teachers, practicing teachers (3-8 years of experience), and experienced teachers. This "professional age" can be expected to have significant impact on the use of technology.

Based on research, theory, and practice, a five-stage framework for effective inservice training has been proposed by Wood, Thompson, and Russell (1981):

1. Readiness - commitment to new professional behaviors
2. Planning - development of design for achieving desired changes in professional practice
3. Training - translation of plans into practice
4. Implementation - integrating change into professional behavior
5. Maintenance - ensuring that change will continue.

It is important to note that readiness precedes all other factors.

This preceding research supports the belief that teachers who possess particular personal or developmental characteristics can benefit from training in use of technology (namely, computers), and can be expected to implement changes in classroom operations. This research also suggests that teachers' attitudes and behavior can be modified and that teachers can be helped to progress to levels of readiness to learn technology, thus enhancing the potential for technology to be implemented into the classroom and curriculum.

The Technology Learning Readiness Scale (TLRS)

Based on attributes identified as prerequisites for successful assimilation and implementation of technology into the teaching/learning environment, the authors have prepared an instrument for gauging readiness for learning the use and application of technology in the classroom. A synthesis of the preceding research forms the basis for selecting teacher characteristics which are proposed as predictors of success in the use of technology. These fall within the following general categories: (1) Managerial, (2) Self directed, (3) Resourceful, (4) Venturesome, (5) Perceptive. A questionnaire to discern these qualities has been prepared and is currently being validated and field tested.

The Technology Learning Readiness Scale (TLRS) questionnaire is designed to elicit responses to questions focused upon attitudes and capabilities of teachers as related to various aspects of the teaching and learning environment which might be either enhanced or impeded by the use of technology (including but not limited to computers). The characteristics identified above have provided the general guidance for development of questions included in the questionnaire.

Methodology

Research on the questionnaire has involved subjecting the instrument and research objectives to face validity evaluation by teacher administrators, instructors of teachers, and teachers themselves. The results at this point have been enthusiastic support for the project. The researchers are currently involved in administering the questionnaire to teachers to acquire the necessary data to conduct the analysis of the effectiveness of the questionnaire.

Along with the questions, the respondents are asked to provide some fundamental demographic information about themselves which may provide some insight into potential modifications for preservice and inservice training. This demographic portion also contains a self assessment question in which the respondent is asked to identify his or her present level of use of technology in teaching. These self assessment levels will be independently confirmed from the teacher's supervisor. The self assessment level will be used as a basis for evaluating the predictive discrimination capability of the TLRS.

Initially, teachers for testing are being selected from school environments which have already made significant commitments of equipment and training in introducing technology into their academic programs. It is expected that the questionnaire will be subjected to several developmental iterations and refinements as test data is collected and analyzed. Each iteration will involve a test group of approximately one hundred subjects.

Data Analysis Procedures

In the evaluation phase, currently under way, the researchers will examine the questionnaire data using statistical methodologies to further refine the questionnaire.

Factor analysis (Norusis, 1985), including factor rotation, will be used to confirm the existence of expected characteristic subscales. While the questionnaire has been constructed on the basis of the anticipated characteristics identified earlier, factor analysis will confirm their existence or assist in identifying alternate characteristic classifications which may be present.

Factors result from item combinations developed from the answers to the questionnaire items which make the inter-item correlation for each factor high, while keeping the inter-factor correlation low. The questionnaire items which contribute most significantly to the development of each factor are specifically identified by the statistical process. An analysis of these specific items will lead to the confirmation of the proposed descriptive factors or the discovery of unsuspected attributes or factors of significance. Factor analysis can also improve the efficiency of the questionnaire by identifying redundant questions, questions which are not statistically significant, or factor groupings which could benefit from the development of additional questions (Kachigan, 1986).

In addition, discriminate analysis (Norusis, 1985) will be used to identify the capability of the questionnaire to predict the expected level of use categories for the subjects. In this procedure, group membership is identified by a technique which produces maximum differences between groups while minimizing the probability of misclassification (Kachigan, 1986). This analysis will be compared for consistency to the self assessment categories selected by the respondents on the demographic information collected with each questionnaire.

The authors feel that the questionnaire will prove capable of discriminating several levels of probable use, which will facilitate refinement of training programs. However, effective classification of prospective users into dichotomous categories of high/active use or low/non use will be completely adequate in targeting activities for teacher developmental.

Conclusion

The purpose of the TLRS is to identify teachers who would be expected to be low or non users of technology in advance of their being subjected to technology training. In addition to identifying these personnel, the TLRS would identify the particular attributes which need development. By performing development training to prepare the user to learn technology, technology training and subsequent technology use by teachers should be greatly improved.

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Windows for Education: Promise or Just Another GUI Mess?

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With the release of Windows 3.0, Microsoft has caused a flurry of computer press activity, and numerous new software products have now been released. Windows has been heralded as the interface of the decade, and even OS/2, the operating system IBM has promised the microcomputer users community, is said to be taking a distant second seat. The educational community must now examine Windows and its competitor to consider their potential benefits to see if they offer a substantial contribution to the way it conducts its affairs. Although the graphical user interface offers a considerably more convenient way of navigating a system, questions remain as to whether it will significantly reduce training demands. Multitasking extends to us a provocative potential, but it is unclear how the average user will make use of it.

Installing Windows is one of its pleasant surprises; the program analyzes your system and accommodates itself to it. Users need to understand the distinction between Real, Standard, and ≠386-Enhanced modes. Real mode is designed for 8086/88 computers with at least 640K of memory and provides few benefits. Standard mode is designed for 286 or higher machines with at least 1 MB of memory, a barest minimum to achieve any respectable performance. Given this configuration, Windows applications can use extended memory and DOS applications can use expanded memory. Enhanced mode is designed for 386 computers with at least 2 MB of memory. In this environment, Windows multitasks DOS, and Windows applications and makes full use of all available memory.

Windows virtually removes the enemy of all uninitiated computer users: the C prompt. Windows loads most smoothly by adding a line to the AUTOEXEC.BAT file. Once loaded, Windows will perform all of the user's daily file management and program control tasks, so it becomes unnecessary to ever invoke a traditional DOS command. Most users will want to establish the Program Manager as the default beginning screen reflecting the Main, Accessories, and Non-Windows Application Windows. The Main Window contains the File Manager icon, and by clicking on it, the user can display a file tree by clicking on any disk drive icon. Additionally, the user can click on the "Disk" pull-down menu and choose from "Copy Disk," "Format Disk," and "Make System Disk." Similarly, it is possible to click on the File pull-down menu to move, copy, or delete a file. No longer is is necessary to memorize the MKDIR and RMDIR commands; instead, you click on a menu item and then simply provide names in a dialog box.

An able but less touted competitor with Windows is GeoWorks' Ensemble. While it performs many of the same functions as Windows, Ensemble requires only an

XT level machine with 512K of RAM, a hard disk with a least three megabytes of space available and any level graphic display. A suite of seven additional applications are included in this package: word processing, draw, file manager, planner, phone book, address book-notepad, and telecommunications software. The program kernel itself is only 55K, including a font manager that provides duplicate screen and printer display.

In spite of its limited hardware demands GeoWorks' Ensemble does "preemptive" multitasking, which means that it allocates resources only to programs that are doing something. Ensemble will not do multitasking of DOS applications, although it will launch them and regain control once the job is finished. A major problem is that software developers must now split their allegiances between Microsoft and GeoWorks, and Microsoft is likely to establish hegemony due more to name than product.

Both Windows and GeoWorks are slick and inviting to use; the real questions lie in whether they are going to reduce the learning curve for educators. Microsoft is disseminating results of a private study indicating that novice GUI users completed 42 percent more exercises than DOS users. One might question claims of such proportions; novice computer user are likely to benefit more than veterans. The real benefit from Windows will likely come from new, more friendly software being released.

An Exploration of Computer Use by Beginning Elementary Teachers

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Computers are purported to have great potential to enhance the processes of teaching and learning. This potential ultimately lies, however, in the hands of the individual classroom teacher (Braun, Moursund, & Zinn, 1990; U.S. Congress—Office of Technology Assessment, 1988). Teachers in general face a complex task as they manage their classrooms, and this complexity is compounded for beginning teachers who are struggling to become comfortable in their new roles. Beginning teachers are traditionally faced with numerous challenges, including the need to become familiar with the content they are required to teach and the materials and methods available with which to teach it. The computer is a new addition to the vast array of teaching resources currently available to teachers, and one which they are often required or expected to use.

Beginning Teachers and Computer Use: The Need for Study

Fulton (1989) points out that although it might seem reasonable to expect teachers fresh out of their teacher preparation programs to be able to use a computer, this is generally not the case. Lawson (1988) indicates that "teachers are emerging from their preservice training to become part of the problem of integrating technology into the classroom rather than part of the solution" (p. 1). Most elementary teachers entering the field today completed their own elementary educational experiences before computers were commonly found in the classroom or linked to the processes of teaching and learning. Many of these same teachers completed their preservice preparation having minimal experience with computers. This leaves the majority of beginning teachers with few examples of instructional computer use upon which to base their own use of computers in the classroom. Yet, these teachers are entering classrooms where computers are available, and where they are often expected or required to use these tools. In many instances, school districts look to beginning teachers, those who are supposedly products of the "Information Age," to use computers in their instruction, as well as to provide a model for other teachers.

Currently, however, little is known about the ways in which beginning teachers use computers or the effects these uses have on beginning teachers.

Purpose of the Study

A qualitative research study was conducted to examine the ways in which beginning elementary teachers use computers in their classroom instruction along with the factors which influence these uses. An exploratory study was carried out to better understand: 1) the nature of beginning teaching experiences; 2) the use of the computer in classroom instruction by beginning teachers; and 3) the interaction between the two.

Methods Used

A case study research design, drawing on ethnographic methods, was used to explore, describe, interpret, and gain the perspective of beginning teachers about their teaching experiences in general and their instructional computer use specifically.

Selecting the participants

Six beginning elementary teachers, described by their district and school administrators as being computer users, were selected as the informants for this study. These teachers ranged in age from 23 to 42, taught in grades two, four, and five, and represented three different middle-class school districts in southeastern Michigan. One of the districts was facing severe financial difficulties and one had strong financial support from the surrounding community. Although none of the districts required computer use among their students or teachers, all "encouraged" it and provided an Apple II series computer in each classroom along with an adequate supply of instructional software. Three of the teachers also had a printer in their rooms, the other three used printers located elsewhere in the school building.

The six participating teachers were all female because no male teachers met the established criteria of being a first-year computer-using elementary teacher with no prior formal teaching experience and no more than three years of substitute teaching experience. Four of the teachers were second-career teachers and two of them took the more traditional path to their first teaching position; together they represented a wide range of formal and informal computer experiences. These teachers were studied during the second semester of their first year of teaching which allowed them time to begin to settle into their professional role, and get beyond merely surviving in the classroom.

Collecting and analyzing the data

The data was collected using various procedures, including: in-depth focussed interviews, classroom observations, informal interviews, and written documents, namely logs maintained by the teachers. Initially, an in-depth interview was conducted with each teacher to develop a sense of her background, beliefs, and experiences. At the end of the interviews, the teachers were asked to maintain written logs for a two week period. The structure for the log entries was provided to them, focussing on their uses of the computer and their reflections about these uses as well as about teaching in general. The interviews were audio recorded and immediately transcribed. Using a constant comparative method of analysis as described by Glaser and Strauss (1967), initial analyses were made, questions generated, and interpretations developed. Questions which emerged from this initial analysis were explored through informal discussions with the teachers, and themes were verified through classroom observations which occurred periodically over a three month duration. These observations provided opportunities to actually see the teachers in action, both when they were using the computer and when they were not. The data from these observations were also analyzed and emerging themes were matched with those found in the interviews and logs.

Upon completion of the classroom observations, composite profiles of each teacher were written. These profiles were shared with the individual teachers and they corroborated the findings revealed in them. Follow-up interviews were conducted after the close of school to discuss the profiles and resolve unanswered questions. This final interview was very informal and allowed the teachers to share their reflections about the development of their professional roles, as well as about their uses of the computer during the year.

Beginning Teachers and Computer Use: A Better Understanding

Although the primary purpose of this study was to explore instructional computer use by beginning elementary school teachers, it quickly became apparent that the computer was not a primary interest or concern for any of these teachers. Although each used the computer, and indeed used it in similar ways and for similar reasons, these uses could not be isolated from the other aspects of their teaching or development as teachers.

Developing as a Teacher

In general, these teachers were typical first-year teachers. That is, they passed through many of the developmental stages associated with beginning teachers and expressed many of the same doubts, concerns, and feelings about their experiences (Fuller & Bown, 1975; Ryan, 1986). They, for example, found this first year of teaching to be an "exciting, challenging, rewarding, and time-consuming" experience. In general, they moved from being "overwhelmed" by their early classroom experiences to gaining control of their situations and settling into their new roles as teachers. Their development as teachers was reflected in their teaching in general and in their computer use specifically. Indeed, instructional computer use provided a lens through which their beginning teaching experiences were viewed.

During the early weeks of the school year these teachers were overwhelmed by the vast commitments required of their teaching responsibilities, including planning lessons, organizing the classroom, learning the routines and procedures of their schools, grading papers, handling correspondence, and attending meetings. They felt they did not have enough time to do all that they had to do, and certainly not enough time to explore with "extras," such as the computer. However, at the same time they knew that their students wanted to use the computer and also felt "expectations" from parents and administrators to use it. Further, they wanted to use the computer because they had strong personal feelings that their students needed exposure to this "tool of the future."

Influences on Computer Use

As the teachers began to settle into classroom routines—about October or November—they found ways to include the computer in their classroom instruction. They often began by instructing the students (as a class) on the operation of the computer and the basics of keyboarding, and then allowing the students to independently complete a drill and practice activity at the classroom computer during free time or work periods. This was a comfortable way for the teachers to use the computer because it matched their traditional or "workbook" styles of teaching. That is, they were most comfortable teaching a "computer lesson" to the class and then having students complete independent follow-up activities, similar to the way they would teach a math or science lesson. They were uncomfortable having the students work at the computer when other activities were going on because it distracted them and the other students as well.

These teachers felt constrained by the limited computer equipment readily available to them (one computer in the classroom) because it was difficult to schedule computer time so that everyone had a chance to use it, because it took the class a long time to complete a computer assignment when everyone had to share the equipment, and because they did not know how to use the computer for whole class instruction. They had few, if any, models of instructional computer use, and were unaware of software which could be successfully used for whole class instruction. In fact, they were unfamiliar with most software and had difficulty in locating programs to truly meet their instructional needs. In most cases, they selected drill and practice programs—often weakly designed programs—which reinforced basic academic skills that the majority of the class had already mastered. However, the teachers felt that the computer enabled them to provide necessary practice in basic academic skills in a "more fun" manner, and thus used it as a reinforcement activity by selecting certain programs for students to use.

Despite the constraints of limited equipment, lack of time, and unfamiliarity with software, the teachers were motivated to use the computer because the students wanted to use it, because it was "fun," because the students needed exposure to it," and because it enhanced the writing process. The most common computer usage in these classrooms was a word processor to enable the students to produce "professional looking documents" and "to free up their writing processes."

Beginning Teachers and Computer Use: Facilitating Change

The findings of this study support the position that teaching, particularly for the beginning teacher, is a complex process and the addition of the computer to the classroom environment adds to the careful balancing act which beginning teachers perform. These findings also contain important implications for teacher educators in their preparation of elementary school teachers in the general sense and particularly about instructional computer use, and for school districts in their induction of beginning teachers and advancement of computer use among teachers.

Implications for Teacher Educators

Given that beginning teachers are overwhelmed by all that they have to do, teacher educators must better prepare them for the realities of the classroom. This can be achieved in two specific ways: the use of case studies and enhanced field experiences.

Case studies, in either the written or visual form, are commonly used in schools of business, law, and medicine to prepare future professionals for the types of situations which they may encounter. They promote discussions of various approaches to different situations, and allow preservice professionals, such as teachers, to apply their knowledge to the solution of a range of realistic problems. Although only a small number of case studies suitable for this purpose currently exist (Bullough, 1989; Bullough, Knowles, & Crow, in press; Christen, 1987; Clark & Florio, 1981), additional ones can be developed, including those which highlight "exemplary" computer-using teachers.

Field experiences, particularly those which require preservice teachers to plan and implement realistic lessons, including lessons incorporating the computer, can also develop a greater awareness of the complexities of the classroom for preservice teachers. Field experiences linked with methods classes are especially useful in providing opportunities for prospective teachers to apply their knowledge and skills. In addition, field placements with computer-using teachers enable preservice teachers to observe models of instructional computer use. Preservice teachers assisting in selected classrooms throughout a term or semester can culminate their field experience with several consecutive days of teaching with lessons prepared in conjunction with their cooperating teachers and university faculty to give them a realistic perspective of classroom management and insight into the teaching process.

Telecommunications, such as a teleconference for preservice teachers, university faculty, and cooperating teachers, can be used to facilitate communication during these kinds of field experiences. The University of Michigan has this type of system in place to promote communication during the student teaching process and to provide a way for student teachers to have continual contact with their university mentors, peers, and cooperating teachers — a network which supplies continual moral support and teaching suggestions (Giamati, 1991; Schumer, 1991). This type of teleconference can also be extended to include first-year teachers as is currently done by the University of Virginia and Harvard University.

Specific to the computer, preservice teachers need direct instruction as well as models of its use for instructional purposes. This suggests a need for teacher education faculty to move away from the traditional lecture mode of instruction to include other methods, including those incorporating the computer. Further, specific instruction about the types of software available, how to evaluate it, and ways to integrate it into the existing curriculum can be added to the appropriate methods courses.

Implications for School Districts

School districts can ease the feelings of being overwhelmed among first-year teachers by providing them with extra time—time to adjust to their new roles, become familiar with their new surroundings, organize their classrooms, plan their instruction, and reflect on their own development. Additional planning periods and reduced work loads are specific ways to provide this necessary time. In addition, mentoring with experienced teachers and support groups for beginning teachers can facilitate beginning teachers' initial socialization into the profession.

Mentoring is a way to facilitate communication among teachers, to reduce the isolation of classroom teaching, and to encourage the sharing of ideas. Peer support groups for beginners, particularly when allotted specific meeting times which do not detract from other responsibilities, provide an important outlet for novice teachers to share their common concerns, problems, frustrations, and successes. It is also a forum to provide specific assistance to beginners, such as ideas for interacting with parents, coping with open houses or reports cards, and classroom management techniques. Again, telecommunications can be used to facilitate communication in the mentoring or support group processes.

Specific to the computer, beginning teachers—even those with computer experience—may need assistance with the logistics of its use in the classroom, such as set up and maintenance procedures, ways to schedule computer use, and tips for using the type of computer in the classroom if it is different from the one used previously. Further, specific information about ways to use the computer for instructional purposes may be needed and can be provided through inservice workshops which demonstrate certain pieces of software and as well as possible uses for them in relation to the existing curriculum. Another way to promote computer use among beginning teachers is to provide an additional computer in the classroom designated specifically for the teacher to assist with the management aspects of teaching, such as record keeping, letter writing, and grading. Inservice programs highlighting these activities may demonstrate the importance and potential of the computer to the teaching process.

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An Educational Experiment With IBM at ISU

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Background

Prior to the end of 1990, the School of Education at Indiana State University offered computer classes only on Apple computers. Since IBM computers have been making significant inroads into the educational market, it was felt that students were not being prepared to use a sufficiently wide variety of computer brands when in an administrative or teaching situation. A grant was submitted to, and funded by IBM Corporation for a networked lab of computers which commenced operation in November of 1990. The grant provided $95,000 for software, $85,000 for equipment and $5,000 for training. Fifteen networked Model 25 computers, two proprinters, a laser printer, an adult literacy station, a desk top publishing and scanner station, and a 125Mb. server were some of the hardware items acquired. Aging Apple computers were removed and a room was renovated in the university campus laboratory school to house the new IBM computers.

Main project goals

1. To establish a networked lab for use by students and faculty of the Indiana State University School (ISUS) and the School of Education (SOE).

2. To enable preservice and inservice teachers to learn how touse IBM computers, peripherals, evaluate software and how to integrate these elements into the curriculum.

3. To provide an opportunity for candidates enrolled in the educational administration doctoral program to learn to use IBM computers as tools to improve school management practices.

4. To afford preservice teachers an opportunity to work with ISUS children and to test self-designed techniques and instructional programs for effectiveness.

Training

The two project directors, Larry Reck and Darrell Swarens, plus two ISUS instructors were sent to the IBM training facility in Atlanta. They also trained with IBM in Terre Haute and Indianapolis.

To determine what curricular content was necessary to meet the needs of future teachers, the two project directors visited high schools within a radius of seventy-five miles to study their computer and preparation programs. Much information was gathered, not only for computer course content but also for other college courses. A state university in Illinois was also visited that had received a similar grant. Courses, experiences, administration of the computer lab, facilities and logistical methods were analyzed to help establish the program at Indiana State

University. Visitation also included a Terre Haute school to observe the "Buddy System" in operation whereby fifth and sixth grade children have computers both at home and in school.

Cooperative Opportunities

One of the major outcomes of establishing the lab facility has been the emergence of a mutually beneficial relationship between ISUS and SOE faculty. Inservice training programs were developed on networking and how instructors can select software for their classes, use word processing, databases, hypermedia programs such as "Linkway," utility programs such as "Grade 1.6," and "Excelsior Quiz" and creativity programs like "Electronic Poet."

Teachers must schedule their classes before they can use the lab which is on a first come, first serve basis. Time has been reserved for inservice activities including time for faculty to come in and use the lab for individual endeavors. The schedule is more than 90% full this semester and students literally run into the lab. Many stay after school until the lights go out in early evening. The project directors have never seen such enthusiasm among children for any other non-athletic school activity.

To publicize our achievement, an open house was held with university and IBM officials in attendance. News coverage was included on local TV and an extensive article on the lab, replete with photos, appeared in the local newspaper. The Indiana State University research journal, and even the university basketball program brochure, carried the news. The Dean of the School of Education cut the ribbon while ISUS's jazz band played. Later, at an all-school open house, children showed their parents what they were doing with the computers. Needless to say, the parents were amazed and impressed with the sophistication of their children

During the summer of 1992, workshops for Indiana teachers, media specialists and administrators will be offered for college credit. Plans for school principal and superintendent sessions are already starting to materialize. Other brainstorming sessions are being planned to help determine other directions and activities.

Cooperation from the local IBM personnel has been excellent. One result of this project has been to enable college instructors to interact with business people and for business people to see how colleges conduct their activities.

The reason for such an overwhelming initial success has been due to the efforts of the full-time lab coordinator, Darrell Swarens. Darrell works with individual teachers and students and is available when a person needs immediate attention with a computer problem. Frustration is kept to a minimum and people leave with a feeling of accomplishment. Without such effort, numerous problems in scheduling, hardware operation, software familiarization and networking would occur.

Summary

The success of this IBM project in the campus laboratory school of the School of Education at Indiana State University has been overwhelming, but also very rewarding. The directors are pleased with the enthusiasm among all those who make use of it. The ISUS and SOE are now moving forward at great speed in educational technology. This achievement will enable present and future teachers, media specialists and school administrators to be at the cutting edge in their respective fields.

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A Concurrent Bilingual, Whole-Language Approach To Programming Instruction

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This ongoing project involves brief programming instruction that may be included in a course on computer literacy for preservice or inservice teachers. This sort of instruction typically focuses on one or more programming languages (often BASIC and/or Logo) for a period of from two to six weeks of a semester. In this project, we propose that computer literacy students be concurrently exposed to two somewhat dissimilar programming languages (BASIC and Logo) in the context of complete working programs.

In the context of programming instruction, a "whole language" environment can be developed by having students spend time with complete working programs from the beginning of the instruction, rather than practicing isolated statements. Although the individual commands in a computer language are related to the semantics of the programs that can be constructed, just as the individual words of natural language are related to the semantics of that language, they can both best be appreciated in context, rather than in isolation.

This project is not "bilingual" in the sense of involving two natural languages. Instead, it involves two computer languages, both of which may be new to the students. Students are exposed to generic programming activities, such as displaying information on the monitor screen or assigning values to variables, as they are implemented in both languages.

In the history of (natural language) bilingual education, many assumptions that might inform this project have been challenged. One old assumption seems to have been that the human mind could only operate under full power if it was undivided linguistically, and that, therefore, bilingualism might be detrimental to intellectual functioning. Peal and Lambert (1962) discovered that fluent bilingual students often had a more diversified structure of intelligence and greater flexibility in thought than carefully matched monolingual children. These results have been replicated, confirmed, and refined in subsequent research conducted around the world by other researchers (Lambert, 1977).

Duncan and De Avila (1979) have argued that in the course of dealing with two language systems, learners develop a facility for figuring out which of their available cognitive schemes are appropriate to a particular situation; this, in turn, increases their capacity for handling new problems.

Based on problem-solving research on analogical transfer, subjects presented with multiple appropriate analogies to a problem solving situation were much more likely to correctly transfer the problem-solving strategy from the analogous situation, even without being reminded to do so (e.g., Gick & Holyoak, 1983; Holyoak, 1985). It seems reasonable to consider the interpretation, creation, and modification of computer programs by students to be problem-solving situations. As a result, it seems likely that the simultaneous presentation of multiple analogies should make transfer more likely. In our situation, the multiple analogies take the form of multiple programming constructs that perform identical or similar functions.

McGrath (1988) argues that when students learn a first programming language, they do not really know anything about programming languages in general. Until they learn at least one other language, they cannot abstract either common or distinct properties of programming languages. That is, after two instances a general schema may be abstracted; after only one instance, it is not as easy to abstract essential properties.

If we agree that bilingualism, at least in natural languages seems to be beneficial, we can still question whether or not both languages should be introduced concurrently. Research on age as a factor in second language acquisition can inform this question. The popular view has been that younger children (language novices) learn second languages much more successfully than older children (with more language experience). This is based on the observation that adults often have difficulty learning a second language whereas, nearly all children exposed to a second langauge eventually acquire a native-like proficiency in its use.

Cummins (1979, 1980, 1981a, 1981b) argues that older students, because they are cognitively more mature, have a definite advantage in dealing with most aspects of learning a second language. These results are consistent with a variety of research studies that compared younger and older students (e.g., Ervin-Tripp, 1974; Snow & Hoefnagel-Hohle, 1978, 1982). Because it takes time to become fluent in a language, younger learners may ultimately have an edge on older ones. It is frequently the case that older learners reach a point in the learning of a new language that is short of native-like proficiency, and they make no further progress. This also happens with younger learners, although it is much less common.

When considering the case of introducing two computer languages concurrently versus sequentially, we can extrapolate the above results to suggest that, at least initially, there may be some confusion as these language novices seek to acquire two languages. In the long run, however, students exposed to a second language while still a novice in the first, may be more likely to develop a mature understanding of the uses, limitations, and appropriate domains of each

Preservice teachers in this project work through "classical" examples of programs relevant to education, such as "drill-and-practice", tutorial, testing, and educational games, making simple modifications and studying the functions of the programs. The examples are always presented in functionally equivalent BASIC and Logo versions. Students are required to make similar modifications to programs in both languages. Students also answer specific questions that require them to not only compare program code and functioning within languages, but between languages. For example, they might be asked to identify which BASIC lines perform the same task as a specific Logo procedure, or what program lines allow the program to perform some specific function (such as offering a hint for an incorrect answer).

The project is still evolving and evaluation to date has been informal. Each semester, students in the course involved have been required to create a multi-faceted project on a personally selected topic. As a part of their project, they are required to either write their own program or modify one of several model programs written in BASIC or Logo. During a semester in which the "bilingual" (BASIC and Logo concurrently) approach was used, 18 of about 150 students chose to work with Logo. (Many who selected BASIC attributed their selection to prior BASIC programming courses; also, our Logo implementation is not particularly "user-friendly.") In the semesters before and after that semester, when both languages were presented independently not concurrently, only 1-3 students per semester even tried to use Logo.

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RESEARCH

This section illustrates not only the wide variety of research being conducted in the field of teacher education and technology but also the application of research to practice in two different aspects of higher education instruction. The section is presented in three distinct parts.

The first part contains two papers which demonstrate general research approaches to program development in teacher education and technology. In the first Neal B. Strudler, from the University of Nevada, Las Vegas, presents the importance of integrating computers into teacher education programs from a collaborative perspective. This paper also discusses the critical role faculty play in program development. The second paper, by Robert C. DiGiulio and Jack P. Calareso, both of The College of St. Rose, illustrates the importance of public school and private sector partnerships in higher education program development. Based on a model developed at their institution, DiGiulio and Calareso focus on involvement of non-higher education agencies in program and curriculum development.

In the second part of this research section, five specific studies are presented—all of which make contributions to the knowledge base in teacher education and technology.

Andria P. Troutman, of the University of South Florida, presents the results of a study which investigated attitudes toward personal and school use of computers. According to Professor Troutman, attitudes toward the use of computers should be an important measure of instructional effectiveness.

In the second paper, Gregg Brownell, Bowling Green State University, with Dieter Zirkler, of the Mead Corporation, and Nancy Brownell, also of Bowling Green State University investigated preservice teachers' perceptions of teachers as computer users. According to Brownell, Zirkler, & Brownell, preservice and inservice teachers' attitudes towards computers will become a critical issue in teacher education as more and more teachers become responsible for using computers in their professional lives.

The third paper, by Hsin-Yih Shyu and Scott W. Brown, both of the University of Connecticut, discusses the use of interactive learning at their institution. Their study dealt with the effectiveness of interactive videodisc systems as compared to traditional textbooks or diagrams in regard to learner control.

The next paper, by Suzi Bogom-Haselkorn and Steven

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V. Owen, colleagues of Shyu and Brown at the University of Connecticut, investigated the effectiveness of anxiety reduction audiotapes on the computer self-efficacy and computer anxiety of college freshmen. In their study, the problem of anxiety reduction techniques with regard to computer use was addressed.

The final study in this section is by Yuen-Kuang Liao and Hersholt C. Waxman, both of the University of Houston. In this study the problem of preservice teachers' misconceptions of computing concepts was investigated. The study was based on the body of knowledge which has identified that misconceptions about a subject can interfere with learning new concepts.

In the third part to this section, two papers demonstrate the application of research into practice with respect to teacher education and technology. The first is by Jim Dunne, from Long Island University. Dunne's paper addressed the use of LOGO to teach programming and higher order thinking skills. The second paper, by Michael P. French, of Bowling Green State University, presents applications of Macintosh software used to enhance the writing process in the instruction of at-risk readers at the Bowling Green Reading Center.

Education Faculty as Change Agents: Strategies for Integrating Computers into Teacher Education Programs

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The most unnoticeable thing in the next decade will be the proliferation of computers to the point where they become utterly unremarkable. —Alan Kay

The above statement articulates a vision that is increasingly being accepted by educators today. Few would argue that computer-based technologies will one day be used as everyday tools in all aspects of the K-12 curriculum. The question then for school districts is how to best implement this innovation and on what timeline. The question for teacher educators becomes equally clear—how can we best prepare teachers to integrate technology into the teaching and learning process? This paper will explore strategies for achieving this goal. Specifically, it will focus on change agent strategies for integrating computers into teacher education programs.

Computer Education: Current Models

At present, computer education for teachers is most commonly implemented through specialized classes taught by faculty well-versed in computer applications. This strategy marks a good beginning toward helping preservice and inservice teachers become familiar with educational uses of technology. In a sense, though, it is analogous to the proliferation of "computer literacy" courses that emerged in elementary and secondary schools throughout the country. Forward thinking educators have viewed such courses as an interim solution that should eventually be replaced by integrating technology throughout the curriculum.

It follows that colleges of education should view computers-in-education survey courses in a similar vein. Research indicates that teachers tend to teach as they have been taught, rather than the way they have been taught to teach. Therefore it seems imperative that teacher educators model the use of technology in their own instruction as well as integrate relevant computer-based technologies into appropriate methods courses. For many university instructors, however, this goal of integration constitutes a major change in established norms, very much analogous to the changes involved in the integration of computers into a K-12 setting. Thus, while the goal of integration is clearly worth pursuing, it will be extremely difficult to implement.

Research Base: The Need for Change Agents

The Rand Corporation in its "Change Agent Studies" found that even the "best" educational innovation is unlikely to fulfil its promise in the hands of an inadequately trained or unmotivated teacher (Berman & McLaughlin, 1977, 1978). Further studies have shown that the successful implementation of innovative programs is dependent upon the intervention of key personnel involved in various *change agent* roles (Huberman &

Crandall, 1982). This emerging role involves attending to the process and training needs of those implementing the proposed change.

At the K-12 level, a growing number of people have been performing such change agent functions as instructional computer coordinators (Bruder, 1990; Barbour, 1986; McGinty, 1987; Moursund, 1985). Consistent with the trend toward process-oriented, school-based change, computer coordinators serve as on-site staff developers and help mold the innovation to "fit" a school's educational program. In addition to dealing with curricular issues, coordinators provide a variety of training and support functions that lead to implementation of computers in their schools (Strudler, 1987; Strudler & Gall, 1988).

A "Game Plan" for Integration: Education Faculty as Change Agents

In view of the difficulty of implementing real change in education (Fullan, 1982), teacher educators should recognize that the long-range goal of integrating technology will not be easy to attain. It's my contention that a change of this scale requires the efforts of one or more faculty members acting in change agent roles. At the University of Nevada, Las Vegas, I articulated and gradually won support for this view, and eventually was allocated released time to serve as the college's instructional computer coordinator. I have worked closely with our college-wide Technology in Education Committee which has provided a clear policy direction supporting the goal of integration. On behalf of this committee, I obtained a Teacher Preparation Grant from the IBM Corporation to support our efforts.

The model for change that we have adopted is based on research on effective strategies for change agents (Miles, 1984; Beaton 1985) and computer coordinators functioning in change agent roles (Strudler, 1987; Strudler & Gall, 1988). School level coordinators employ a variety of product- and client-centered strategies to facilitate computer use. These strategies include obtaining necessary resources, providing training and follow-up support, organizing lab facilities, energizing and motivating teachers, collaboratively helping teachers to find computer applications to "fit" what they do, and gradually "weaning" teachers of their dependence on the coordinator. Effective strategies take into account the "plight" of teachers who are burdened by existing responsibilities.

An implicit assumption of this model of change is that it would be very difficult to implement by mandate. Rather, our approach has been to begin with faculty members who are open to the increased use of technology, support their efforts, and work to establish a critical mass of involved faculty.

Strategies for Integration: What's Working (So Far)

The key strategies discussed in this section are organized into four clusters: (1) collaborative problem solving, (2) resource adding, (3) training and follow-up support, and (4) organizing and preparing.

Collaborative Problem Solving is a critical strategy for obtaining broad-based support for a program's goals. When I arrived at UNLV in 1989, I became a member of the college's Technology in Education Committee. Our first priority that year was to submit a proposal to the IBM Teacher Preparation Grant Program. While it might have been more expedient for me to have written the proposal myself, by working together, we arrived at a shared vision and a sense of collective ownership. Also, our final product clearly benefitted from broad input. In addition to curricular components in mathematics and science education, the proposal was strengthened by components in special education and educational administration. In our case, the "whole" product benefitted from the collaborative process. This is consistent with findings of the Rand Study (Berman & McLaughlin, 1978) which suggests that involving broad participation facilitates commitment as well as more informed decision making. Also, this process established a positive framework for our long-range goal—the integration of computers into our entire program.

Collaborative problem solving is also important to help individual faculty members "fit" various computer applications into what they're doing. This involves getting a sense for what is being taught in various methods courses and how computers might fit in. Effective coordinators need to listen to colleagues and make informed suggestions based on that professor's educational objectives and readiness to take risks with technology.

Resource-adding addresses a major impediment to the integration of computers in educational programs—insufficient computer and human resources. One approach to overcoming inadequate resources is to seek grants from outside sources as well as funds from the university. A broad base of support is clearly helpful in obtaining such funds. Furthermore, successful resource-adding does a great deal to enhance the credibility of the coordinator and the program. In fact, as Rogers (1983) found, credibility is positively associated with change agent success.

Effective resource-adding takes into account the utility and user-friendliness of the resources as well as the needs of the faculty and students. Sometimes technologically-oriented decision makers are so enamored with the power of technology that they lose sight of what will make a real difference for a majority of users. For example, the chair of our college technology committee has been a strong proponent of establishing a local area network in the college that ties into the university's backbone. While all committee members supported that goal, some argued that our top priority should be to first obtain a desktop computer and application software for all faculty members who request it. We successfully argued that using computers for professional productivity is a critical first step toward integrating technology into our program. Although adding the network would have benefitted some of the faculty, it would not have made a difference for the majority. In fact, it would have caused a great deal of resentment. If faculty perceive that decision makers are benefitting personally at the expense of other faculty, it will likely be counter-productive for the goals of the program.

Since allocating funds for desktop computers, the question of the network is again being considered. This time, in addressing the question of how the network will help our faculty, we have begun to focus on one obvious benefit—*easy* access to electronic mail. My vision in this regard is to invest some of the available funds to obtain a user-friendly interface to make e-mail accessible for all users, not just battle-worn veterans of our mainframe's cryptic operating system. This seems to be a critical prerequisite to establishing electronic mail as a standard way of doing business in our college.

An often overlooked resource in innovative programs is the time required to attend to the many details necessary for implementation. In considering this, I wrote into our IBM grant proposal that our dean would allocate released time for me to coordinate the program. When I passed a draft of the proposal to our dean, I highlighted that paragraph and asked for a response. He replied, "Go ahead and get the grant." We did, and I then had a written commitment for that much-needed human resource—time to coordinate the program.

Resource adding could also involve the search for new faculty. At UNLV we have experienced vast growth in the past few years and have hired a number of new people. Since our staff development needs are already significant regarding educational computing, it makes sense to try to bring in new people who already have those skills and perspectives. With this in mind, I have made a point to actively participate in faculty searches. While we of course want to hire the most qualified candidate, I have argued that knowledge of educational computing should be considered as a desired qualification. In recent searches for various postions including our new chair, that qualification was written into job descriptions.

Training and follow-up support is a critical, yet often neglected component of innovative educational programs. My strategy for training has focused on working with groups and individuals to help faculty: (1) become more proficient with various computer applications for professional productivity, and (2) become aware of how computer applications can be integrated into their content area. In each of these areas, I have attempted to be available for follow-up support. Research suggests that "one-shot" inservice sessions do not effect significant behavior change (Berman & McLaughlin, 1977; Fullan, 1982; Joyce & Showers, 1981, 1983); but continued training, when coupled with appropriate follow-up, can be effective.

Regarding group training, I have attempted to inform faculty about university-wide inservices that introduce various computer applications and to supplement these offerings with workshops that are particularly suited to the needs of educators (e.g., providing an overview of available resources, using electronic mail, using a spreadsheet for grades). In addition, I have worked with individual faculty on learning projects of interest to them (e.g., establishing a children's literature database).

In all cases, being available for follow-up support seems critical in providing technical assistance as well as a reassuring "pat on the back".

Another strategy that I have "borrowed" from effective K-12 computer coordinators is to teach model lessons with computers in various education classes with the hope that the attending professors will eventually incorporate computer applications into their university teaching. Usually this has involved giving a brief overview of computers in that particular content area, followed by an opportunity for students to "play" with and evaluate appropriate software. My only requirement is that the professor attend the session. Thus far, my experience has been that professors are able to see that: (1) their students are motivated to work with computers, (2) computers can enhance teaching and learning in their content areas, and (3) it is feasible to use computers in their teaching. The goal, then, is to provide the continued support and gradually "wean" faculty so that they no longer need help. One pitfall in this regard is to mistakenly assume that once faculty have been exposed to computer use in their classes, they can then easily "take over". Effective coordinators must assess the comfort level and technical expertise of the professor and continue to provide support as needed.

Organizing and preparing involves attending to the many details that are necessary for faculty to use computer technology in their teaching. This includes helping to schedule lab use, facilitating access to appropriate hardware and software (establishing procedures to check out software, LCD panels, etc.) and in general, "being around" to help ensure that things go smoothly. While it's not necessary that the coordinators personally attend to all of these details, it seems critical that they facilitate the process. As Huberman and Crandall (1982) state in their study of innovative programs, "Innovations entailing significant practice change live and die by the amount of assistance they receive" (p.76).

Conclusion

The long-range goal of integrating computer technology into teacher preparation programs will not be easy to attain. Drawn from research on successful computer implementation in K-12 schools, I have suggested a model for change in which university faculty function in various change agent roles. I have outlined specific strategies and described initial efforts to implement them. Clearly, further dialog as well as systematic study of these issues is needed to inform integration efforts in the coming years.

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An Integrated Approach to Research and Development of Technology in Education

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Introduction: A Three-way Partnership

Over the years there has been no shortage of criticism leveled at our education system. At least since the time of Dewey, an enduring comment is that school is inauthentic; divorced from reality and thus devoid of meaning (Kelley, 1947). At one end, colleges are "ivory towers", guilty of having "failed democracy and impoverished the souls of today's students" (Bloom, 1987). At the other end, elementary and secondary schools are driven by mindless low-level tasks, obsessed with routine and regulation, and emphasizing choice at the expense of knowledge (Hirsch, 1987). Teacher education programs—the "bridge" between college and schools—have escaped none of the critics' wrath, assailed as being behind the times, unrealistic, and insubstantial (Koerner, 1963; Parsons, 1985). Perhaps the most recurrent complaint has been the fragmentation of education (Powell, Farrar & Cohen, 1987). From preschool through college, students proceed through programs compartmentalized and fragmented, allowing little opportunity to draw conclusions, to see connections between concepts, or to form generalizations that lead to understanding.

This fragmentation also exists in the educational structure itself: There is little contact between elementary/secondary schools and colleges, between preservice and inservice teacher settings. The only real connection is student teaching. Yet once a student has graduated, even that tenuous bond is severed. Thus, even today it remains a shock for the new teacher who leaves the "ivory tower" to enter the "salt mines", facing alone some twenty to thirty not-all-eager faces.

There is a solution that will bridge the gulf between school and college. Over thirty years ago, Jerome Bruner was hopeful of "teaching machines" that were coming into use in the classroom. They would not replace the teacher (he reassured anxious educators), and they could even bolster the teacher in many ways. He said "How these aids and devices should be used . . . is, of course, the interesting problem" (p. 84). Bruner thus accurately identified the challenge that lay not in devices (hardware), but in their utilization. Today, after thirty years of technological improvements in "teaching machines", no teacher needs to be isolated from allies: other teachers, professors, schools and colleges. Although they are no panacea for our alleged educational ills, there is little question of the advantages computers can bring to the process of education (Slesnick, 1985; Weir, 1989). In short, technology exists to bridge the gulf between college and school; between "ivory tower" and "salt mine."

Indeed, that bridge can also include the world of work. American business has taken a keen interest in education. Typically, this has been expressed through "partnerships", where business, in conjunction with, for example, higher education, generates resources to help bring about a better result for student learning. There are indications that such partnerships can be fruitful.

Recently, a partnership of school, computer manufacturer, and university developed a program and software that helped teachers teach eight-year old children with cerebral palsy to read (Gall et al., 1989). A similar partnership installed "Writing to Read" computer labs in 55 rural West Virginia, Kentucky and Virginia schools (Childers, 1989). Results were encouraging: participating students' writing and spelling achievement was better than that of non-participating students. Teachers regarded the computer lab program with enthusiasm, benefitting from inservice training they received.

Most early partnerships of this type emphasized "devices"; their objectives were to install hardware and provide software to schools. This made sense because few schools had microcomputers or peripherals in the "dark ages" of the 1970's. Hardware is still fundamental and well-written educational software is to be esteemed, yet we now know that the key to making them work is the educator; the teacher. In fact, the classroom teacher has been singled out to be crucial to the successful use of computers in the school (Chan, 1989a, 1989b; Trollip & Alessi, 1988; Weir, 1989). A teacher's positive attitude toward computing almost predictably increases microcomputer use (Clariana, 1990; Martin, 1988). Hence, a partnership has to involve the teacher, and its goals and objectives have to include enhancing teacher attitudes toward computers. Simply stated, the latest hardware accompanied by a cornucopia of software cannot do the job.

Origins and Goals of the Partnership

Surprisingly, few partnerships have focused directly on the teacher, especially the preservice teacher. In an attempt to meet that concern the College of St. Rose entered into a partnership in fall, 1990 with the IBM Corporation and the Voorheesville (New York) Central School District in cooperation with the New York State Education Department as part of a technology in the classroom project. In January, 1990, the New York State Regents had issued a report entitled "Long-Range Plan for Technology in Elementary and Secondary Education in New York State." This report focused on the strategies for achieving excellence in schools. The Regents concluded that "The foundation for pursuing excellence in schools should be thoughtful curriculum development and deliberate, cooperative curriculum implementation . . . aimed at increasingly more effective classroom instructional practice." To achieve this goal, the Regents recommended "the complete integration of technology into the teaching/learning environment of schools." Therefore, the specific purpose of the cooperative project among St. Rose, IBM, Voorheesville and the State was to conduct research and develop strategies to determine how best to use available technology resources to improve the efficacy of instructional practice and achieve school excellence.

To model and reflect both the cooperation and mutuality necessary to achieve this goal, the College adopted an integrated approach to the project by forming an interdisciplinary Project Team, consisting of members representing Divisions of Education, Cognitive Studies, and Business. Specific areas of expertise include elementary education, secondary education, special education, reading, adult education, educational administration, educational psychology, computer information systems, mathematics, and business administration. Team members provide expertise and experience in a variety of curricular areas, teaching strategies, and technological application.

Goals of the Project

The initial goals of the project team involve three major areas:

1) The development and implementation of undergraduate and graduate teacher education programs which both utilize available technology and develop skills necessary for the professional use of technology by teachers;

2) The development and delivery of preservice and inservice teacher training programs in using technology for instruction and for instructional support applications;

3) The dissemination of findings on the impact of technology in schools and education training centers.

To support the efforts of this project, the College is in the process of creating a multipurpose computer lab. This lab is to serve as a dedicated research center for the project team and project participants, as well as a demonstration classroom and instructional center for teachers and teacher education students. It is expected to be fully operational by summer, 1991. Once the multipurpose lab is operational, the team will work closely with teachers and students of Voorheesville Central School District. In addition, several other school districts in the Albany area have been invited and have agreed to participate in both research and application phases of the project.

Initially, the project will actively involve undergraduate and graduate students, staff and faculty at the College. This has already begun through the College's graduate level "Computers in Education" course. It is a required course for elementary education and school counseling majors, and is an elective available to other majors. Because it is taken by many preservice and inservice educators, the course is a logical starting point to help ascertain the needs of preservice and inservice teachers in upstate New York's Capital District region.

Educational Dimensions to be Addressed by the Project

Phase 1: Acquiring Basic Facility

A. Prior to the course. Current research indicates that the best way to bring about positive change in schools with regard to microcomputer use is to first enable teachers and other educators to acquire personal facility before attempting to use computers with students (LaFrenz & Friedman, 1989; Martin, 1988). Thus, it was decided that educators who registered for the spring 1991 course "Computers in Education" would receive a needs assessment survey form in November, 1990. The needs assessment would measure the educator's personal background and experiences with computers and computing.

The needs assessment revealed little difference in "computer literacy" levels: It was low for both preservice and inservice educators. Simply because an educator was working as a teacher or counselor did not mean that she or he had familiarity with computers. In fact, some preservice educators (those with no prior professional experience in education) were likely to have more experience with computers than experienced teachers. This was usually due to business applications connected with present or prior employment.

Educators' level of computer expertise was assessed to find a starting point of instruction for the course. This coincided with a literature review to identify requisite competencies for professional educators. These included: reading and writing simple programs; using accurate computer terminology; utilizing educational programs and documentation; recognizing limitations of educational use of computers; locating information on computers; and discussing both historical and moral issues related to using computers (Anderson, 1983). A course syllabus was then developed which highlighted six broad areas of instruction: (a) A history of computers and computing, (b) The origins and philosophy of computer use in education, (c) Contemporary educational uses of computers and computing (d) Computer hardware, (e) Computer software, and (f) Issues in computers and computing. (A copy of the course syllabus can be obtained by contacting either of the authors.)

B. During the course. Preservice and inservice educators who took the course were exposed to a novel presentation of material instead of extremes of lecture-only or unstructured "computer literacy" exercises. Importance was placed on "the '-ing' in computing", emphasizing an active, doing approach to microcomputers. Through brief demonstrations and hands-on use of high-interest educational software, educators personally discovered educational uses of the computer. Low-level facts were gradually incorporated, but only after a context existed for those facts. For example, the function of a central processing unit (CPU) was discussed only after students identified—and then physically removed and examined—a real microprocessor from a microcomputer. Instruction was delivered in Bruner's three modes of presentation, viz., symbolic (words, lectures), iconic (pictures, audio-visual aids) and enactive (concrete, hands-on). Because the latter concrete mode is effective for the naive learner, activities included "dissection" of a computer and a disk drive, as well as construction and use of simple programming, integrated spreadsheet applications, and methods for evaluating and using educational software. Guided by current issues in educational computing, students researched an interest area of computers in education (such as artificial intelligence or distance learning) and communicated the results through a class presentation.

Once the course began, needs assessment continued. This ongoing needs assessment was accomplished through guided questions, and has revealed what may be called a "fear factor". Inservice teachers and educators require a friendly computer literacy approach. Both adult and child learners respond well when they can make connections between what they already know and what they are expected to learn. Prior to the course, some students had been "turned off" to computers, because they were either kept from them or were taught the most unfamiliar parts of the computer, parts that remained unfamiliar. Some students described feeling very inadequate when computer literate persons used unfamiliar words. Emphasis on arcane terminology and jargon (e.g., "content addressable memory" or "forty meg hard drive") are best avoided, especially early in any computer literacy course. We must be careful not to emphasize mastery of intricate technical data by educators, especially not at the price of losing global understanding, knowledge, and an appreciation of how the computer can be used to benefit the student.

To address the "fear factor", it was decided that an instructional strategy for the course would be taken from that of a quality science instruction: students would be allowed to freely investigate and inquire.

Phase 2: After Acquiring Facility

This phase will begin once teachers have acquired a basic knowledge of, and facility and comfort with microcomputers. It is anticipated that, after this has been accomplished the needs of preservice teachers and inservice teachers will diverge. Accordingly, these diverging needs will be identified, and the diverse talents and areas of expertise available among College faculty will be mobilized to meet those needs. It is anticipated that a number of research foci will be established involving the Voorheesville School and centered in the multipurpose computer lab. Anticipated research foci include research on the efficacy of computer-aided instruction in elementary and secondary school classrooms, development of specific undergraduate and graduate courses on technology in instruction to be initially piloted in summer, 1991; review and evaluation of existing software programs and applications; investigation of gender differences toward educational computing; and research on the efficacy of technology in diagnostic assessment (including creation and management of test banks).

Additionally, we hope to evaluate and document the educational benefits of Technology Network Ties (TNT). TNT is the electronic network of the New York State Education Department designed to link students and teachers with worlds outside the classroom. Consistent with the foci of this project, attention will be given to the potential benefits of TNT to teachers in terms of electronically interacting with their colleagues, identifying special resources for improved instruction and sharing effective teaching methodologies. These activities should lead to both improved curriculum development and more appropriate staff development activities.

Conclusion

It is expected that key questions will be at least partly answered by the end of 1991. Now that the computer "honeymoon" period of the 1970's and 1980's has passed, it is time for educators to objectively (and fearlessly) assess the advantages that computers bring to elementary, secondary, and college classrooms. The success of an integrated approach to technology in education will ultimately be measured by the improvement of learning. However, the key to success will be best understood in terms of the changes in teacher attitudes as classroom-based technologies become richer sources of instructional activities, positively impact teachers' managerial responsibilities and provide the critical link to a more global partnership in education.

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Attitudes Toward Personal and School Use of Computers

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Introduction

Educational researchers and practitioners agree that course evaluations should rely on a number of variables. Variables such as student evaluations, student growth with respect to course goals, student attitudes and behavior changes, and efficiency of course management are accepted as important variables to consider when evaluating a course. With the growing availability of microcomputers in schools, it is particularly important to develop school personnel who not only have the knowledge to use computers, but also have the confidence and willingness to explore computer technology to invent and implement new models for instruction. It is especially important to measure the effectiveness of instructional computing courses in terms of attitudes toward the use of computers in schooling, attitudes toward personal use of computers, and growth with respect to learning sound ways to integrate computers into the instructional or managerial process.

Purpose

This study had two main purposes. The first purpose was to design two Likert Attitude Scales: *Attitudes Toward the Use of Computers in Schooling* (ATSC) and *Attitudes Toward Personal Use of Computers* (ATPC). The second purpose was to examine the relationship between attitudes toward personal use of computers and school uses of computers. The ATSC scale measures attitudes toward the general use of computing in the school environment for instructional or management purposes. Specifically, this scale is to focus on attitudes related to how individuals in certain groups perceive (1) the potential usefulness of computers for instruction and management; (2) the feasibility of using computers in school environments for instruction and management; (3) how computers might enhance affective outcomes in schooling; and (4) the dependence of society on a computer literate citizenry.

The ATPC Scale measures attitudes toward personal use of computers in terms of (a) usefulness, (b) interest, (c) confidence, and (d) stereotyping of computer users. The initial target audience for development of the scales consisted of 292 pre-service teachers enrolled in a course entitled *Introduction to Computers in Education*. This is a required course for all education majors at the College of Education, University of South Florida.

Related Research

A review of the research literature revealed only a few studies that involved the development of valid and reliable scales for measuring attitudes toward computers and none were found for measuring attitudes toward the use of computers in schooling. Gressard and Loyd (1985) reported the development of the Computer Attitude Scale

(CAS), a Likert-type instrument with 30 items relating to three factors—usefulness, interest, and confidence. The CAS was subjected to three validation studies. Participants were elementary, middle school, and secondary teachers. Results of the three validation studies indicate that: (a) the scores of the three subscales are sufficiently stable, (b) the CAS has reasonable convergent validity; and, (c) the CAS is sensitive to attitude changes resulting from computer instruction and experience. Richards (1986), describes the development of a scale designed to assess some basic student attitudes about computer usage. Bear (1987) reported the development of a scale designed to measure elementary and secondary students' attitudes toward computers. Each of these studies involved scales unique to the goals of the researcher and the respective target audience. Of the three, the Gressard and Loyd study serves as the best model for the current study in that it is an aggregate of subscales assumed to represent independent factors. However, the Gressard and Loyd scale does not include items related to the stereotyping of computer users. None of the scales dealt specifically with school uses of computers in a comprehensive sense.

Methods and results

An item pool was collected for each scale. Each item pool was generated from a variety of sources—computer educators, graduate students, prospective school teachers, practicing school teachers, and lay citizens. Each item was examined to determine its appropriateness. Several types of items were discarded:

1. Cognitive statements that could elicit the same response from two different individuals, one having a positive attitude and one having a negative attitude. For example, the item "Computers are too expensive for education". was eliminated.
2. Facts such as "Using a computer requires learning new skills".
3. Compound statements such as "It should be a top priority to train all teachers and school administrators to use a computer." were either eliminated or rewritten as two items.

A set of four judges independently sorted the items to ensure that each item fell within the limits of the identified constructs. The resulting pool for the ATSC pool contained 46 items and that for the ATPC contained 21 items. For each item, respondents were to select one of the following: strongly agree, agree, neutral, disagree, or strongly disagree to express their agreement or disagreement with the item. Both scales were administered to 292 pre-service teachers. Each item was scored on a five-point continuum, 5 points for strongly agree, 4 for agree, 3 for neutral, 2 for disagree and 1 for strongly disagree. To obtain attitude measures, the total of item scores was computed for each scale. A high score on either scale indicates a positive attitude, while a low score indicates a negative attitude. Initial responses for negative items were reversed so that scores obtained on negative items would be consistent with the method used for finding total measures of attitudes. Percentages of respondents selecting each possible response, the mean score, standard deviation, and item discrimination index were computed for each item. The item pools were refined on the basis of these statistics. Items that spread respondents out among categories and had a high index of discrimination ($p>=.50$) were retained. To ensure stability of each scale Cronbach alpha coefficients of reliability were computed: alpha R(ATSC)=.97 and alpha R(ATPC)=.90 The refined ATSC contains 32 items and the refined ATPC contains 19 items. A correlation of total scores for each of the two scales was computed to determine the degree of relationship existing between attitudes toward personal use of computers and computing in schooling. (C=.80)

A summary of the statistics is provided in Table 1 below.

Table 1

Data summary for the ATSC and ATPC scales

	ATPC	ATSC
Items in initial pools	21	46
Items in refined pools	19	32
Reliability	0.90	0.97
Correlation of total scores ATSC and ATPC	.80	

Conclusion

The possible range of scores on the ATSC scale was High(ATSC)=160, Low(ATSC)=32. The possible range of scores on the ATPC scale was High(ATPC)=95, Low(ATPC)=19. The mean score for the ATSC was 125, while that of the ATPC was 54. These data indicate that the general attitude of the population was positive. From the correlation data it can be concluded that education majors at the University of South Florida who feel secure in their own personal use of computers, also feel positive toward the use of computers in schools. Further research is needed in many areas. First of all, each scale should be subjected to factor analysis to determine if constructs such as usefulness, interest, etc. are independent constructs and, if not, what factors are being measured by the scales and how these factors relate to overall measures of attitude. Further evidence of validity should be gained by examining pre and post measures in courses where instructional goals involve improving attitudes toward the use of computers. Also studies should be conducted to determine how knowledge of, or prior experience with computers relate to attitudes.

Scale Items

The following are lists of the items for both attitude scales.

Attitudes Toward the Use of Computers in Schooling

____ 1. Training teachers to use computers should be a high priority.

____ 2. Using computers in school management will improve the operation of most schools.

____ 3. With computers we have the opportunity to improve instruction.

____ 4. The evil of computers in schooling is that they will eventually replace a lot of good teachers.

____ 5. School students would find learning with computers challenging and interesting.

____ 6. Using computers to learn will diminish the physical fitness of students.

____ 7. Most any educator can find a substantial use for a computer.

____ 8. Most school administrators should learn to use computers.

____ 9. A computer is nothing more than a glorified typewriter attached to an electric calculator.

____ 10. Lessons on computers can be effective because they can correct student errors immediately.

____ 11. Learning through the use of computers is dull and repetitious.

____ 12. Using computers in the classroom will create cold classroom atmospheres.

____ 13. The use of computers in schooling will erode the privacy of teachers.

____ 14. Using computers in schooling is just another fad that will be replaced with some other fad sooner or later.

____ 15. Using computers to teach is not anymore effective than using good books so why go to the expense of putting computers in schools.

____ 16. Effective administrators do not need computers to operate schools efficiently.

____ 17. Most teachers should learn to use computers.

____ 18. If computers are used in schooling, students will not develop basic skills.

____ 19. Computers will only put more work on the shoulders of school administrators.

____ 20. Students who learn using computers will have a definite advantage in life over students who have not learned to use computers.

____ 21. The use of computers in schooling will erode the privacy of students.

____ 22. Effective teachers do not need to use computers in their teaching.

____ 23. Using computers with young children will destroy their ability to develop good keyboarding skills and we will end up with a world full of people who "hunt and peck".

____ 24. Computers can be used in courses such as English, Art, Music, Creative Writing just as well as with courses in Science and Mathematics.

____ 25. With computers educators have the opportunity to transform outmoded methods presently used for schooling.

____ 26. Students who use computers to learn with will become passive students.

____ 27. If we had better trained teachers we would not have to worry about using computers in education.

____ 28. Lessons on computers can be effective because they can correct student errors in a private impersonal way.

____ 29. With the right computer learning, students could learn to take greater responsibility for their own progress.

____ 30. With the right computer learning, students could develop more confidence in their ability to learn.

____ 31. Many teachers will not be able to learn to use computers no matter how they try.

____ 32. I feel confident that I could organize instruction for my students using computer programs that "instruct".

Attitudes Toward Personal Use Of Computers

____ 1. I would almost rather do anything than to work on a computer.

____ 2. I'm too active to get stuck sitting behind a computer.

____ 3. People who like to use computers are book geeks.

____ 4. I think I would feel powerful if I could use a computer well.

____ 5. I would rather achieve my goals without using a computer.

____ 6. I am afraid to use a computer.

____ 7. I would enjoy the challenge of using a computer.

____ 8. I don't feel sure of myself when it comes to learning to use a computer.

____ 9. I think it would be fun to work on a computer.

____ 10. I think that I can be more productive if I learn to use a computer.

____ 11. I think it is okay for a male to use computers, but it's not okay for females.

____ 12. I avoid computers.

____ 13. People who play games on computers don't have much social life.

____ 14. I am afraid that I can't learn to use a computer.

____ 15. Computers are very interesting.

____ 16. A computer can do some good for just about anyone.

____ 17. Computers are for sissies who want to sit around.

____ 18. A computer could help me accomplish some important personal goals.

____ 19. I think I would enjoy playing games on a computer.

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Preservice Teachers' Perceptions of Teachers as Computer Users

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Introduction

The influx of computers and instruction with and about computers has been a key theme in education over the last decade. Bruder (1988) has estimated that there are almost 1.5 million computers available in schools in the United States for students in grades K through 1. Students at every level have a good chance of gaining instruction about computers at a variety of levels as they pass through the education system. Also during this period, there has been increased interest in the educational opportunities provided to preservice teachers so that they may be adequately prepared to both use computers in the teaching of traditional content areas and instruct students about computer use (Brownell, 1990, Taylor, 1988).

As more and more teachers become responsible for using computers in their professional lives, preservice and inservice teachers' attitudes towards computers becomes an issue (Jay, 1981, Lawton & Gerschner, 1982; Stevens, 1980). Cambre and Cook (1984) found that teachers, with respect to computers, had a higher level of anxiety than did their students, while Koohang (198~ ound that previous experience with computers (and the type of experience) was related to attitude about computers.

While the importance of both preservice and inservice teachers' attitudes toward computers has been established, one area not yet investigated is preservice teachers' attitudes toward teachers as computer users. An undergraduate may become comfortable with computers during schooling, but the student may need to make a conceptual jump to see the profession of teaching as one which requires computer use as the norm. If prospective teachers are to use computers and technology in their teaching, they must view teachers as computer users. They will then perceive a typical teacher in much the same light as someone characterized as a person who uses a computer at work.

Purpose

This study addresses preservice teachers' perceptions of six characteristics (comfort with the computer, personal adaptability, gender, time spent with people, gaining efficiency by computer use, and programming a computer) as related to a typical teacher versus those same characteristics as related to a typical person who uses a computer at work. The following hypothesis was investigated:

There will be no significant difference between preservice teachers' perceptions of a typical teacher versus their perceptions of a typical person who uses a computer at work, for the characteristics of comfort with the computer, personal adaptability, gender, time spent with people, gaining efficiency by computer use, and programming a computer.

Method

The subjects for this study were 331 undergraduates identified as elementary education majors. Subjects were enrolled in either a course entitled Introduction to Teaching (51.7%) or a course entitled Computer Utilization in the Classroom (48.3%) and were comprised of 3.5% Freshman, 48.1% Sophomores, 33.4% Juniors and 15% Seniors. Subjects were primarily female (91.8%). Data on subjects' GPA was also gathered and categorized as High (above 3.10) Medium (2.66 - 3.10) or Low (Below 2.66). Percentages of subjects' in each group were: High, 31.3%; Medium, 35.8%; and Low; 32.9%.

Using factor analysis, an 11-item instrument was developed to measure subjects' perceptions of an individual identified as a typical teacher, and to measure subjects' perceptions of an individual identified as a typical person who uses a computer at work, for the characteristics of comfort with the computer, personal adaptability, gender, time spent with people, gaining efficiency by computer use, and programming a computer. Figure 1 shows the characteristics and the associated items. Two characteristics (comfort and adaptability) are measured by the identified subscales while others are measured by the identified single items. The items were placed in random order. Response to each item was on a five-point Likert scale ranging from 1 (Strongly Agree) to 5 (Strongly Disagree). Two versions of the instrument were created. On the first version, subjects were asked to first respond to the 11-items in regard to a teacher who uses a computer at work. Immediately below the 11 items, the items were repeated again, but this time the instruction was to respond to the items regarding a typical person who uses a computer at work. The second version of the instrument was exactly the same except responses for a typical person who uses a computer at work were elicited first, then responses regarding a typical teacher. Subjects were randomly assigned to receive one of the two versions of the instrument. At the beginning of the semester during the second week of classes, subjects received and responded to the instrument.

Results

A repeated measures ANOVA was used for each characteristic to analyze subjects' perceptions of a typical teacher versus a typical person who uses a computer at work and also to investigate any interaction between 1) subjects' responses and GPA, and 2) subjects' responses and year in school (Upper = juniors and seniors versus Lower = freshman and sophomore).

Table 1 gives the repeated measures ANOVA results. As identified in the table, significant differences were found at the $p < .001$ level between students' perceptions of a typical teacher and their perceptions of a typical

Characteristic	Item(s)
Comfort	Enjoys using a computer. Feels in control of a computer when using it. Gained a solid computer background in college. Has very strong math skills.
Adaptability	Is flexible and adaptable in performing his/her job. Has many interests in addition to his/her job. Is skilled at working with people.
Gender	Is a male.
Time with People	In a typical day, spends most of his/her time with people.
Efficiency	Becomes more efficient at his/her job by using a computer.
Programming	Writes computer programs for his/her job.

Figure 1. Characteristics and associated items used to gauge preservice teachers perceptions of a typical teacher versus a typical person who uses a computer at work.

Characteristic	DF	SS	F value	p>F
Comfort	1	69.86	234.34	0.0001*
Adaptability	1	91.86	460.46	0.0001*
Gender	1	31.86	77.67	0.0001*
Time with People	1	485.61	814.70	0.0 *
Efficiency	1	65.41	163.26	0.0001*
Programming	1	149.53	209.17	0.0001*

* p<.001

Table 1.
Repeated measures results by characteristic for preservice teachers perceptions of a typical teacher versus a typical person who uses a computer at work.

Characteristic	Computer User	Teacher
Comfort	2.27	2.96
Adaptability	2.43	1.64
Gender	3.86	4.33
Time with People	3.28	1.44
Efficiency	1.81	2.49
Programming	2.47	3.49

[1]Note: Possible responses ranged from 1 (Strongly Agree) to 5 (Strongly Disagree)

Table 2: Means by characteristic for preservice teachers perceptions of a typical teacher versus a typical person who uses a computer at work[1]

person who uses a computer at work, for each characteristic investigated. No interaction with either GPA or year in school was found.

For the characteristic of gaining efficiency by computer use, main effects were found for year in school (Upper versus Lower, $p < .05$) and for GPA ($p < .01$). A Tukey's Multiple Comparison test for the GPA main effect revealed that there was a significant difference between the High GPA group and the Medium GPA group as well as between the High GPA group and the Low GPA group. No significant difference between the Medium and the Low GPA groups was found.

Discussion

Table 2 presents the means by characteristic for students' responses for both a computer user and a typical teacher. As previously noted, each set of responses, by characteristic, is significantly different. An investigation of the means presented sheds some light on the perceptions students expressed.

For the computer comfort category, items citing actions or experiences which may be seen as leading to comfort with the computer students see a typical teacher as less comfortable with a computer than a computer user. However, students are very close to undecided about the characteristic of comfort with computer use as applied to a typical teacher. At least students do not see a typical teacher negatively in regard to comfort. Many students may themselves be on the fence regarding computer use and might be leaving the door open about what they will be comfortable with as a teacher. Many may have realized that the use of technology in teaching will be required of them and may, on some level, be working toward becoming comfortable with that requirement.

With respect to the category of adaptability, descriptors that tend to denote flexibility and a "people" orientation, students see a teacher as more adaptable than a computer user. Interestingly, the mean for the computer user tends toward the positive. Students do not seem to subscribe to the stereotype that computer users are unable to work with people and so choose to work with machines.

Gender expectations appear to be strongly female for the responses regarding a typical teacher (between Disagree and Strongly Disagree for the statement, Is a Male). This matches the distribution in the sample, which was 91.8% female, and mirrors the fact that the population of elementary teachers is overwhelmingly female. Again however, it is interesting that students did not expect the computer user to be male, since the mean in this category for the computer user responses was 3.86, very close to disagreeing that the computer user would be male. Perhaps another stereotype, this one that computing is a male domain, is being dissolved, at least in this sample of preservice teachers.

Students see a teacher as more likely to spend time with people than a computer user would. They see a teacher as likely to spend most of the day interacting with people. This might be expected, since teaching is a profession which requires frequent, intense interaction with people. However, responses regarding a computer user tended somewhat toward disagreeing that most of the day would be spent interacting with people. Many users of computers on the job do spend most of the day interacting with people. There may be a vestige here of a computer user being seen as a programmer who spends most of the day with a machine. In opposition to this are the many jobs where computer use is important, but frequent interaction with people is also important. For example, lawyers, secretaries, musicians, and managers make use of computer applications in a variety of ways but are readily involved in interacting with people.

Students saw the computer user as more strongly gaining efficiency via the computer. Their responses regarding a teacher were about half-way between "Undecided" and "Agreeing". Once again, this may have something to do with the learning process the students are passing through. They may be in the process of learning exactly what the computer can do for them, as future teachers, to help them be more efficient. In fact, the main effect for year in school indicated that the Upper group (juniors and seniors) had a stronger perception that a computer was a way to gain efficiency than did the Lower group (freshman and sophomores). Increased practice with technology as students progress through their college years, may lead to a greater understanding of what can be expected from technology. This is a good argument for technology infusion throughout the teacher education curriculum. In the other main effect found, the students in the High GPA group were more likely to link computers and efficiency than were students in either the Medium or Low GPA groups. An interesting question here would be: "Are better students more likely to see technology as an aid, or does the use of technology help to improve GPA?"

In regard to the programming characteristic, students did not see teachers as writing programs as part of their work, but they tended toward seeing the computer user as writing programs.

Conclusion

With respect to the characteristics investigated in this study, do preservice elementary teachers see a typical teacher in the same way they see a typical person who uses a computer at work? The answer is clearly no. Computer users are seen as more comfortable with the computer, more likely to gain efficiency through its use, and less likely to interact with other people than a teacher. If preservice teachers are to integrate technology into their teaching they must begin to see themselves as people who use computers at work. They must perceive teaching as one of the many professions that routinely and successfully uses the technology of the twentieth century.

On the positive side, it appears that students may be beginning to see themselves as computer users. It appears that juniors and seniors see the relationship between computer use and efficiency more strongly than do freshman and sophomores. In addition, some of the stereotypes we might have seen were not present. A computer user was not viewed as a male. Computer users were *not* characterized as being inflexible and oriented away from other interests, or as having no skill in working with people. These may be indications that attitudes toward technology may be changing.

If we hope to affect education positively with technology, over the long run and in a meaningful, widespread way, then teachers must begin to see themselves as users of technology. Stereotypes surrounding the use of technology must be addressed and alleviated. Future teachers need to understand the importance of technology in their professional and personal lives and in the lives of their students. For teacher educators this means providing meaningful, positive experiences with computers and associated technology. It also means addressing, in a variety of ways, stereotypical views of computers. This means that in addition to providing preservice teachers with relevant skills, we also need to address relevant issues surrounding technology. Such issues include gender and minority equity issues, society and its relation to (and dependence upon) technology, job opportunities and requirements regarding technology (both now and in the future), stereotypes surrounding technology, science and math, and how they are related, and issues regarding technology as an emancipating, humanizing force as opposed to uses of technology that enslave and dehumanize. By providing such a conceptual basis for students as a background to the skills we seek to impart, students can become truly educated about technology and its role in society and education. Most importantly, students will not only see themselves as computer users, but they will *want* to see themselves as *teachers* who are computer users.

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Letting the Student Choose: A Study of Interactive Learning

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Introduction

As the videodisc becomes popular, the role of learner control has gained recognition in the field of computer-based instruction. Because the videodisc provides random access to video or audio capability, learners are able to access all the material, at any time, in any sequence they wish. Therefore, the learners can, and do, have control to direct their learning process. Some evidence has suggested that learner-control improves student performance (Campanizzi, 1978; Gray, 1987; Shyu & Brown, 1990) and attitudes (Lahey, Hurlock & McCann, 1973), reduces instructional time (Lahey, 1976), and may enhance the feelings of self-efficacy and self-determination (Papert, 1980). However, learner control is not limited to computer-based and interactive videodisc instruction; there may be considerably more learner control possible with a traditional textbook (Merrill, 1984). To some extent, learners may exercise more content and display control with a textbook, because they may manipulate the pace and the order as well as "look back" where they feel it is needed. Research on the effects of learner control tends to focus on the use of the interactive videodisc systems (IVS). The question of the effectiveness of learner control available in traditional textbooks or diagrams has largely been ignored.

According to Hunt, Pellegrino, Frick, Farr and Alderton (1988), pictures which do not contain any moving elements are referred to as static-medium displays, and those with moving elements are referred to as dynamic-medium displays. Since an IVS may provide learners with a more vivid and stimulating instruction by its dynamic elements, it is possible that IVS (a dynamic-medium display) may result in greater learning than traditional texts (a static-medium display), even if the latter is able to provide as much learner control as the former one. The difference may be the dynamic aspect of the displays.

Research in the area of IVS tends to compare the effectiveness and efficiency of an IVS and a traditional classroom teaching. For example, Slike, Chiavacci, and Hobbis (1989) provided evidence that college students in an IVS instruction took one-third less time to learn as many sign language vocabularies as those in a traditional classroom approach. Soled, Schare, Clark, Dunn and Gilman (1989) found that students respond more favorably to an interactive videodisc instruction than a traditional lecture in a nursing course. Leonard (1989) investigating college students' perception of an interactive videodisc learning system as an alternative to the conventional laboratory, suggested that the IVS provided more experimental and procedural options, and a more efficient use of time than the conventional mode.

A meta-analysis performed by the United States Department of Defense examined thirty-one studies concerned with interactive videodisc (Fletcher, 1989). Across the evaluation studies reviewed, IVS instruction was reported to be more effective than conventional approach to instruction. IVS was also found to be "... a promising and cost-effective medium that will have a significant impact on military systems ..." (p. 8). Findings related to the effects of the IVS have generally been positive, although some evidences indicated students using IVS did not learn more (Ebner et al., 1984; Soled et al., 1989).

Among the studies conducted in the area of IVS, the majority compared IVS with a traditional classroom teaching. Little research has been conducted analyzing differences between an IVS and a traditional text or diagram, in a setting of individualized instruction. Most would agree that there is a difference between learning from a classroom lecture and from a textbook or a diagram (Merrill, 1984). Merrill (1984) indicated that lectures, tape/slide presentations or movies, as examples of linear delivery systems, made the reordering of content components difficult, even though students could still choose to skip some components merely by "turning off" during a given presentation. However, those delivery systems become much more difficult in presentations which require active student participation or responding, than in expository presentation. On the other hand, Merrill (1984) also states that "... workbooks, textbooks and other traditional materials which are manipulated by the learner in a self-paced individualization study mode enables the learner to exercise some degree of pace, content, and display control" (p.6). Furthermore, it is assumed that individualized instruction always involves some form of learner control.

Smith (1988) examining the effects of IVS versus text/ diagram in individualized instruction, indicated that elements of dynamic graphics in IVS did not result in significant gains in achievement or attitude for teaching medical students. Shyu, Garry, Kim and Brown (1990) also demonstrated that IVS did not significantly facilitate student performance in a procedural task.

In contrast, Davis, Matin, and Miller (1989) conducted a study to compare three methods for teaching freshmen how to use the library's on-line catalog. The three methods were video projection, dual television monitors (these two were combined as a dynamic-medium group) and overhead transparencies (a static-medium group). The results indicated that the dynamic-medium group achieved significantly higher scores than the static-medium group. The students also indicated a significant preference for the dynamic displays (video and TV) over the static displays (overhead transparencies). The conflicting research findings may be due to the unavailability of learner control in the IVS, or variations in the nature of the instructional task.

Furthermore, research concerned with adapting instructional treatments to individual differences among student aptitudes has been termed aptitude-treatment interaction (ATI) (Cronbach & Snow, 1977). ATI studies have suggested that one learner characteristic affecting the efficiency and effectiveness of learner control is relevant abilities (Fry, 1972; Snow, 1980). ATI studies also indicate that low ability students benefit more from structured instruction and high ability students benefit more from unstructured instruction. Therefore, ATI effects would be represented by an interaction effect between display type and ability group.

Self-efficacy is an individual's belief about his or her ability to plan and execute a particular behavior (Bandura, 1977). As students have more efficacious behavior, they are more likely to believe that they can accomplish tasks and therefore are also more likely to engage in tasks, and persist once initiated. An accumulating body of research suggested that learners' self-efficacy is an excellent predictor of student attitudes and accomplishment (Froman & Owen, 1990; Schunk, 1989).

In this study, a procedural task was used. The instructional task was the making of an origami (paper-folded) crane. The learner controls available to both IVS and diagram groups were pace, content, and display control as defined by Merrill (1984). The current study not only attempted to confirm Davis et al.'s (1989) findings, but also examined student's self-efficacy, as well as applied learner's relevant ability in a learner-controlled ATI design.

The purpose of this study was to investigate the effects of dynamic (IVS) versus static display (diagram) on student performance score, self-efficacy, attitude toward instruction, and instructional time in a procedural task. The ATI effects between treatments and the students' ability relevant to the task was also examined.

In this study, subjects used their spatial-visual rotation ability to create an origami crane. Therefore, the relevant ability to the task was student's mental rotation ability as measured by Vandenberg's *Test of Mental Rotation* (MRT) (Vandenberg & Kuse, 1978).

In keeping with the above considerations, there are two primary questions to be addressed by this study. First, by providing the same amount of learner control in the setting of individualized instruction, does an IVS improve student learning significantly beyond a traditional diagram for: (a) making an origami crane, (b) the attitude toward instruction (c) self-efficacy of making an origami crane, and (d) the time to complete the instruction? Second, are there ATI effects between the treatments (IVS or diagram) and students' relevant ability (high and low mental rotation ability) on each of the four previous variables?

Method

Subjects And Design

Subjects in the present study were fifty-six volunteers from an undergraduate class at the University of Connecticut. None of subjects had prior experience with origami. A 2 x 2 factorial design was used. Subjects were randomly assigned to receive either an IVS or a diagram treatment. The independent variables were treatments (IVS vs. diagram) and mental rotation ability (high vs. low). The dependent variables were subject performance score in making the crane, post-instruction self-efficacy, attitude toward instruction, and instructional time.

Procedures

Any student who indicated experience with origami were eliminated from this study. Only novice students were retained as subjects in order to minimize possible contamination from earlier experience. All subjects were first administered the *MRT* (Vandenberg & Kuse, 1978) before the treatments. A median split was performed to differentiate students with high mental rotation ability form those with low mental rotation ability. Then, subjects were randomly assigned to one of the treatments (IVS or diagram). Both treatment conditions utilized individualized instruction; no group instruction was provided. After the treatment, the subject's origami performance score, attitude toward instruction, post-instruction self-efficacy, and instructional time, were measured.

Treatments

Two instructional treatments were used: IVS group and diagram group. Both groups were encouraged to practice folding the crane during the instructional phase and they were provided with an unlimited supply of origami paper. All subjects in both groups were found to have practiced during instruction.

The diagram group (N=28) was provided with a well published manual (Harbin, 1969) designed for developing origami. The IVS group (N=28) was presented an IVS format of "Making an origami crane" using *The First National Kidisc* (Green, 1981). The videodisc had been re-purposed to allow for computer access to control both video and narration sequences as well as student selections, so that the presentation was learner-controlled, interactive, and compatible with that of the diagram group. Subjects in the IVS group were provided a menu from which to select instructional segments. Subjects were also provided a suggested instructional path (i.e., path with advisement). The advisement was used to make subjects aware of the decision-making process required to select the next step in the instructional sequence and to suggest the most appropriate sequence. Subjects went through the program based on their own choices and order. At each instructional segment, subjects could repeat, stop, or continue the segment at any given point. They were able to view the instructional segments in any order they wished. They were also able to go back to any segment they wanted to see again.

Instrumentation

Subjects created the crane using their spatial orientation and visualization abilities. The *MRT* (Vandenberg & Kuse, 1978) was employed to determine their spatial-visual rotation ability before the treatment. The *MRT* has been identified as a reliable test for spatial visualization ability (.83 to .88) (Wilson et al., 1975).

Subjects in each group were administered a single item measure of self-efficacy using a Likert-type 5-point response scale (1=Not at all confident, 5=Very confident) after instruction.

An attitude questionnaire, using Allen's *Semantic Differential Tool to Measure Attitude toward Computer Assisted Instruction* (Allen, 1986), was completed by each subject after treatment. The Allen's CAI attitude scale has been reported to be a reliable and valid tool, with an internal reliability estimate (Cronbach's alpha) of .85 and content validity as determined by an 80 percent agreement among a panel of five judges (Allen, 1986).

The test crane (performance) was scored blindly by two origami experts. The correlation of scores assigned by the two raters was .95. The time to complete the instructional program was recorded by the computer for each subject to provide a time-based indicator of learning efficiency across the instructional treatments. The diagram subjects also had their instructional time measured using the computer to record the start and finish time.

Results

The data were analyzed using a 2 x 2 (treatment x mental rotation ability) Multivariate Analysis of Variance (MANOVA) because of the inter-correlations among the dependent variables. Box's M test was first employed to check the MANOVA assumption of equal covariance matrices. The test showed equal matrices among the groups, and the analyses proceeded. The results revealed a significant MANOVA main effect for treatment ($F(4,49)=6.94$; $p<.001$). Follow-up univariate ANOVAs indicated significant differences on attitude, ($F(1,52)=26.66$; $p<.001$), and self-efficacy, ($F(1,52)=4.98$; $p<.05$). The subjects in the IVS (dynamic display) group felt more confident and had a more positive attitude towards instruction than those in the traditional diagram (static display) group. No significant differences were found on either their origami performance score or the time to complete the instruction.

Although a significant MANOVA main effect was not initially found for the high and low mental rotation groups on the origami performance score ($p>.05$), follow-up analysis driven by our original hypotheses revealed that subjects with high mental rotation ability performed better on the creation of the origami crane across both treatments ($F(1,52)=4.33$; $p<.05$). The results of the posttest self-efficacy measure indicated that the difference between the two groups approached significance ($p=.06$) suggesting that the high ability subjects had greater self-efficacy than the low ability subjects. Additionally, no ATI was found.

Discussion

The overall results suggested that traditional diagrams may work as effectively and efficiently as IVS on student performance in procedural learning. However, students have significantly more favorable attitudes and have greater self-efficacy in IVS instruction than diagram instruction.

This study is significant because it provides empirical evidence of no significant difference existing between diagrams and IVS on learner control instruction, and no ATI between two mediated displays and relevant ability in procedural learning. However, in this study, students displayed considerably more favorable attitudes toward IVS instruction, and IVS instruction resulted in higher self-efficacy for completing a procedural task. Both of these findings have important implications regarding the long-term impact of IVS on student attitudes and self-efficacy as they are related to students achievement on procedural tasks.

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The Effectiveness of Anxiety Reduction Audiotapes on the Computer Self-Efficacy and Computer Anxiety of College Freshmen

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Introduction

The intent of this study was to investigate the effectiveness of anxiety reduction audiotapes on the computer self-efficacy and computer anxiety levels of college freshmen in a compulsory introductory computer class. It was thought that anxiety reduction techniques used to reduce fears associated with a variety of anxieties would also influence computer anxiety. Reduced anxiety improves the likelihood of success, which in turn fuels self-efficacy.

The sample studied were freshmen at a state university and included both male and female undergraduates (n=40). Percentages of males to females were 35% and 65% for the experimental group (n=20), and 45% and 55% for the control group (n=20). Gender differences and previous computer experience were examined as potential variables affecting self-efficacy and anxiety. The effectiveness of the anxiety reduction audiotapes were assessed using the *Computer Self-Efficacy Scale* (*CSE*) (Murphy, Coover & Owen, 1989) and the Computer Anxiety Subscale of the *Computer Attitude Scale* (*CAS*) (Lloyd & Lloyd, 1985).

Procedure

The *Computer Self-Efficacy Scale* (*CSE*) was administered to both the experimental and control groups four times, while the Computer Anxiety Subscale was administered pre and post. The anxiety reduction audiotapes contained two types of anxiety reduction techniques: relaxation and cognitive restructuring. While relaxation techniques have indicated effectiveness in reducing anxiety, research suggests that combining relaxation techniques with methods affecting thought processes, provides a more effectual method of coping (Denney, 1980; Meichenbaum, 1985). Students listened to the audiotapes six times per week for three weeks, a total of 18 times. Adherence to listening was assessed using two self-report forms. The *Listening Form* asked students to report when, where and how often they listened to the audiotapes. The *Evaluation Questionnaire* assessed students' knowledge of the exercises contained in the audiotapes and their perceived ability to apply them.

Results

After controlling for initial differences in previous computer experience, a repeated measures ANCOVA indicated the anxiety reduction audiotapes were ineffective in significantly increasing the computer self-efficacy and reducing computer anxiety levels of the experimental group over the control group. However, this analysis did indicate a significant improvement in computer self-efficacy and computer anxiety over the duration of the study.

Alternative sources of self-efficacy information were available to both groups through regular classroom participation. These sources included personally experienced successes and failures with computers and the observed successes and failures of others (Bandura, 1986). The female computer instructor may have provided a vital source of self-efficacy information for the women in both groups. Although women were thought to have lower computer self-efficacy percepts than men, gender was found to have no significant relationship to computer anxiety or computer self-efficacy. However, resulting means on self-efficacy and anxiety measures indicated a greater increase for females than males, over time. The pre to post *Computer Self-Efficacy Scale* means were 2.64 and 3.85 for women and 3.07 and 3.85 for men, on a five-point response scale. The pre to post Computer Anxiety Subscale means were 2.70 and 2.97 for women and 3.02 and 3.19 for men, on a four-point response scale.

Discussion

The ineffectiveness of the anxiety reduction audiotapes could have been due to the availability of additional sources of computer self-efficacy information such as personal experience and modeling. This information was available to all students as part of the classroom experience. In social cognitive theory, efficacy beliefs and anxiety interact: perceived competence diminishes anxiety about task performance (Bandura, 1986). Once anxiety is reduced, the chances for success increase, fueling self-efficacy. Therefore factors influencing computer self-efficacy also affect computer anxiety. The amount of self-efficacy information available in the computer classroom experience may have been sufficient to improve the computer self-efficacy and anxiety levels of both groups of students.

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Preservice Teachers' Misconceptions of Computing Concepts

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Introduction

Recently, there has been an emphasis on examining how students view concepts in areas such as mathematics, science, and computer programming (Confrey, 1990, Wittrock, 1986). Several studies have found that students often have wrong ideas or misconceptions about basic concepts and that these misconceptions can function as a potential barrier to the assimilation of new learning (Confrey, 1990; Perkins & Simmons, 1988). Although there have been a few studies that have investigated the types of systematic errors or bugs that individuals make while computer programming (Pea, Soloway, & Spohrer, 1987; Stemler, 1989), studies have specifically investigated preservice teachers misconceptions about computing concepts.

In one study that focused on preservice teachers' misconceptions, Galloway (1990) investigated preservice teachers' development and attainment of computing concepts during a computer literacy course. The results of the study indicate that preservice teachers in a computer literacy course had limited understanding of the fundamental computing concepts such as *file*, *data*, *command*, *program*, and *language* as well as limited ability to explain and discuss these concepts. Galloway's study was exploratory, however, and consequently has limited generalizability due to it's very small sample size

The objective of the present study was to explore the effects of (a) taking a computer literacy course, and (b) previous computer experience on preservice teachers' misconceptions of computing concepts.

Fundamental Computer Concepts

The computer concepts selected to be examined in the present study were (a) *command*, (b) *data*, (c) *file*, (d) *program* and (e) *language*. These concepts are fundamental in the operation of a computer and are commonly taught in many computer literacy courses. The definition for each of these concepts and the relationships among these concepts can be easily misunderstood and confused.

Galloway (1987, 1990) has developed a theoretical model to demonstrate the relationships among these concepts. In this model, he defined *command* as an instruction to the computer that calls for an immediate action. *Computer data* is information typed into the computer by the user. It is also information reported to the user which is generated by the computer itself. A *file* is a named location on a disk which contains some type of information, either a computer program or stored data. A *computer program* is a list of instructions (commands) designed to program a task or tasks. The term *computer language* refers to the set of rules which allow the computer to interpret commands as calling for some specific action and establish the allowed syntax for commands. The five computer concepts selected for the present study followed the theoretical model developed by Galloway (1987, 1990).

Method

Subjects

The subjects in the present study were 123 preservice teachers from two state-supported, public universities located in a major metropolitan city in the southwest. Nearly 90% of the subjects were female and about 81% of them were white. In addition, 54% of the subjects were between the age of 18 and 25. Both of the universities that participated in the present study have similar undergraduate teacher education programs in which an introductory computer literacy course was required for all preservice teachers. Also, the background characteristics and attitudes of the preservice teachers from these two institutions have been previously found not to be significantly different from each other (Waxman, Freiberg, Clift, Houston, & Knight, 1989). In the present study, 61 preservice teachers from one of the institutions had just completed an introductory computer literacy course, while the other 62 preservice teachers from the other institution had not yet taken a computer literacy course.

Computer literacy course

The content of the computer literacy course taught by one of the universities involved in the present study included: (a) word processing, (b) database, (c) spreadsheet, (d) Logo, and (e) BASIC. This model of computer literacy was consistent with that proposed by Thompson and Friske (1988) in which several applications were emphasized and programming was only a component part. The course was taught in a networked Macintosh computer lab. The general expectation for that course is for preservice teachers to achieve a simple level of operation of applications software (e.g., word processing) and to write simple programs in Logo and BASIC. In addition, these preservice teachers were also expected to develop an understanding of computing, social issues regarding computer use, and the historical development of computer technology. Although it is not an emphasis in the computer literacy course, the development of a conceptual base of problem-solving skills from the course was also expected.

Instrument

The instrument used in the present study was a computer concept test developed by Galloway (1987, 1990) that was designed to measure preservice teachers' misconceptions of the computing concepts of (a) *command*, (b) *data*, (c) *file*, (d) *language*, and (e) *program*. The test consists of 40 multiple choice questions, eight on each of the five concepts. The test has been found to be reliable and valid, and has been previously used with

Table 1

Means, Standard Deviations, and Analysis of Variance Results by Group

	Computer Literacy Course (n=61)		No Computer Literacy Course (n=62)		
Variable	***M***	***SD***	***M***	***SD***	***F***
File	5.02	1.28	5.40	1.55	2.22
Data	4.18	1.75	4.15	1.34	.38
Program	4.15	1.46	4.69	1.54	5.21*
Command	6.36	1.57	6.32	1.32	.05
Language	4.83	1.52	5.10	1.10	.78
Total Score	24.51	4.75	25.66	3.56	2.12

Note: The maximum possible score for each variable is 8.
The maximum possible total score is 40.

* $p < .05$

preservice teachers (Galloway, 1987, 1990).

Procedures

Near the end of the Fall academic semester, all the subjects completed the 40-item test. The data was collected and coded. A 2 x 3 factorial analysis of variance (ANOVA) was used to investigate if there were any statistically significant ($p < .05$) differences: (a) between groups (i.e., those who had taken/not taken the computer literacy course), (b) among students who had different levels of prior computer experience (i.e., less than 1 year, 1-2 years, and more than 2 years), and (c) the interaction between group and computer experience.

Results

The overall descriptive results indicated that on average, preservice teachers scored about 25 out of a possible high score of 40 on the computer concepts test. The group which did not take the computer literacy course scored slightly higher than the group that completed the computer literacy course. Moreover, preservice teachers with 1-2 years of computer experiences scored slightly higher than those with less than one year or more than two years computer experiences. For each concept tested, the highest mean values were for the concepts of *command* and *file*, while the lowest mean values were for the concepts of *data* and *program*. In general, the standard deviations were low indicating that there was not a great deal of variance in the ways these preservice teachers responded to these items.

The ANOVA results indicated that there was only one statistically significant difference between the groups. No significant differences were found among levels of computer experience and no significant interactions were found. Table 1 reports the means, standard deviations, and analysis of variance results by group. The only significant difference was between groups on the *program* concept ($F = 5.21$, $df = 1/122$, $p < .05$). The group which did not take the computer literacy course scored significantly higher on the *program* concept than the group that completed the computer literacy course. Although not statistically significant, it should also be pointed out that the overall total score for the preservice teachers not taking the computer literacy course was higher than the group who had taken the course.

Discussion

The results of this study indicate that generally, preservice teachers had limited understanding of the fundamental computing concepts tested. In addition, the findings suggest that taking a computer literacy course may not influence preservice teachers' understanding of the fundamental computing concepts. Also, the finding that there were no significant differences among students with different computer experiences suggests that longer exposure to computers does not necessarily increase students' understanding of fundamental computing concepts.

The finding of a significantly higher score for preservice teachers who did not take the computer literacy course on the *program* concept reflects that preservice teachers possibly developed more confusion regarding this concept after a short period of exposure to programming, since programming was only a component part of the computer literacy course. The finding is also similar to the results of Galloway's (1987) study in which the *program* concept was the least improved among other tested concepts from a pretest/posttest comparison. In order to improve preservice teachers' misconceptions regarding the *program* concept, a longer period of time learning programming might be required.

The findings from the present study suggest that teacher educators in computing may need to employ strategies that change preservice teachers' naive views or misconceptions of computing concepts into a more sophisticated scientific point of view of the world. This model of instruction has been called *conceptual change teaching* (Novak & Gowin, 1984; Posner, Strike, Hewson, & Gertzog, 1982). This model suggests that we first need to examine the views that students hold of computing concepts and then take into account their perceptions and viewpoints before building on them and/or modifying their ideas. Instruction, from this perspective, suggests that computer teacher educators should integrate new knowledge with students' prior knowledge of scientific phenomena. Thus, effective computer education instruction has the instructor probing students' understanding of scientific phenomena and then using the indications from these probes to reach the deeper understanding that they represent. Prior experience with computers and completing a computer literacy course may not be sufficient to address students' misconceptions of computing concepts.

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An Analysis of the Skills and Knowledge Necessary to Teach Programming as a Vehicle for Developing Higher Order Thinking Skills

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Introduction

The major justification for teaching children to program is that it will lead to the development of problem solving and higher order thinking skills. Research on the effectiveness of programming as a vehicle for developing higher order thinking indicates that skilled and knowledgeable teachers are essential for successful implementations. Yet most elementary and secondary programming teachers lack both the technical and pedagogical skills required to be effective programming teachers.

The most successful educational innovations demand the least amount of change in the organizational structure of a school and in the behavior of teachers and students (Cuban, 1986). This helps to explain why the most common current use of computers in classrooms is for drill and practice. The content and methodology used in this technology is familiar to all teachers; it does not require them to obtain new knowledge or skills, and it can be easily integrated into mainstream classrooms.

Using the Logo language to create a programming environment for the purpose of fostering higher order thinking skills, on the other hand, usually requires organizational, curricular, methodological, and behavioral changes in the classroom (Dunne, 1990).

The complexity of creating an effective Logo programming environment will always be a difficult task. Helping teachers to develop the skills to become competent programmers and to create effective programming/learning environments will be an essential element of any successful implementation.

Interpreting Logo as a Delivery System

The programming language Logo was designed to provide children with an environment rich in interesting things to do and to think about. In the process of learning and using Logo, children are thought to develop higher order logical/mathematical skills that are applicable to a much broader range of tasks than just programming. These skills are developed in the course of the child's intrinsically motivated explorations of Logo microworlds. These explorations require the child/programmer to engage in self-reflective behaviors that will lead to a better understanding of, and control over, his or her own thought processes.

Many early interpretations of Logo made the assumption that since the language was supposed to be part of an exploratory and discovery based learning environment, explicit teaching would not be necessary. Students would be provided with enough information to get started, but most language features and programming strategies would be learned or emerge from the process of programming. Allen & Davis (1984) contend that this approach to programming instruction borders on sadism and usually leads to frustration and failure.

The most critical and influential interpretation of Logo as a treatment that will deliver higher order skills is found in research conducted by Pea and Kurland (1984) at the Bank Street College of Education. Their major criticism was that "the Logo instructional environment that Papert offers to educators is devoid of curriculum, and lacks an account of how the technology can be used as a tool to stimulate students' thinking about such powerful ideas as planning and problem decomposition. Teachers are told not to teach, but are not told what to substitute for teaching" (pp. 44).

In assessing why Logo has failed to meet the expectations of many of its early researchers and users Weir (1987) explained that "Logo is not to be viewed as some patent medicine, good for everything regardless. Nor will its benefits emerge as an automatic consequence of its use. Unfortunately, an impression was gained from the early descriptions of Logo that putting the child together with a computer equipped with Logo was all that was required" (pp. 10).

Solomon (1986) also claims that this was not the intention of Logo's developers. She describes Logo as providing the environment or culture in which the teacher (expert) and the student (novice) can find common ground to discuss their projects (goals) and the problems (bugs) they encounter, and how to identify and build on the knowledge they will need to accomplish their goals. In addition to helping to structure the environment so that the children avoid unprofitable or unnecessarily frustrating paths, teachers also learn about their students, themselves and the content they are exploring.

Logo and Teacher Education

Teacher education in programming is inadequate and unless there is a major effort to improve and expand it, the educational promise of programming instruction will never be realized (Bork, Pomicter, Peck, & Velso, 1986; Dalbey & Linn, 1986; Linn, 1985; Lochhead & Mandinach, 1986; Mandinach, 1986; Michayluk, 1986; Weir, 1987; Wright, Melmed, & Farris, 1984). The study by Wright, Melmed, & Farris (1984) found that the majority of K-12 teachers who taught programming were essentially untrained, with under 60% of them rated by their principals as being at least *minimally* qualified to teach their courses.

In his analysis of Logo use in schools, Becker (1987) notes that while many Logo teachers understand and advocate the Logo philosophy, "the actual classroom practices of these teachers is not as distinguishable from other computer-using teachers as their ideas about the value of using computers. Many, if not most, classrooms that use Logo appear to be rather traditional environments" (pp. 12). While many schools have bought into the educational promise of Logo, they haven't made the investment in time, training and equipment that achieving the promise will require.

As Shank (1984) points out, "it is very demanding to teach programming in such a way that it can sharpen a child's thinking ability. Programming instructors in schools haven't learned to teach programming that way. The ideal programming teacher has to really understand, in a fundamental sense, how to create algorithms, and what a process-based system is all about. Most importantly, he must teach these things in a lively, relevant, and interactive manner" (pp. 202).

Since most programming teachers have had little actual programming experience, they have a limited understanding of what programming is all about. They usually teach according to this limited knowledge and rarely develop expectations for their courses beyond introducing the syntax and semantics of the language. Usually teachers are either unaware or incapable of using programming as a vehicle for introducing higher order skills.

Weir (1987) notes that the typical teacher education course in programming doesn't begin to provide teachers with the skills and knowledge necessary to teach it. She states that "providing good models is more important than supplying prescriptive curricula . . . teachers are learners, too, and need messing about, safe places in which to try things out, and a community of learners and relationships they can trust" (pp. 232). Like their students, teachers will need the opportunity and time to actually program, solve problems, and work on extended projects. This should provide them with the necessary experience and insight into the possibilities of programming to create programming cultures for their students. As Pea and Kurland (1984) realized as a result of their research, higher order skills such as planning are "not guaranteed by the Logo programming environment; they must be supported by teachers who, tacitly or explicitly, know how to foster the development of planning skills through the judicious use of examples, student projects, and direct instruction" (pp. 44).

The Role of the Teacher in a Programming Environment

Before students can begin to use a programming language in any kind of creative way, they'll need at least a basic mastery of the commands of the language and some knowledge of how those commands can be used to accomplish a task. Some kind of explicit teaching is necessary to achieve this (Clements, 1985, 1986; Dalbey & Linn, 1986; Perkins & Martin, 1986; Swan & Black, 1987; Weir, 1987). The structure and type of teaching will vary according to the particular resources and constraints of the class. It seems obvious that students need to be exposed to the tools, skills, strategies, concepts, and models of programming in order to understand, use, adapt, and make them their own. To accomplish this, Leron (1985) calls for Logo environments "in which there is a more active role given to teachers and learning materials, but the atmosphere of exploratory and meaningful learning is maintained" (pp. 47).

After the focus of instruction has moved beyond the syntax and semantics of the programming language, explicit instruction is still necessary. In a study of the transfer of problem solving strategies in a Logo environment Black, Swan, and Schwartz (1988) concluded that transfer could be explained by "deliberate, forced attention to well-defined problem solving ideas, the explicit modeling of the metacognitive behaviors involved in problem solution, the required working through and corresponding proceduralization of problem solutions, and the attempt to acquaint students with the deep structures of the problem domain and of specific problem solving techniques" (pp. 393-394).

This type of direct intervention in programming environments is usually described as guided discovery. Gallini (1985) describes guided discovery in Logo as a way for the teacher to help "make the learner aware of the problem-solving process, i.e. to enhance metacognitive skills. ... Through questions the student is brought to think about how the problem was actually solved, in contrast to the traditional focus on having the learner merely communicate the final solution. ... The learner can be presented with a set of questions that "channel" his or her thinking about the actual process involved in using Logo to arrive at a solution." (pp. 8).

Groen (1981) describes this as the teacher engaging in a Socratic dialogue with the learner, where the teacher guides by asking appropriate questions. The questions are used to help the students elaborate on their own thinking. They encourage the students to focus on things that need further attention, or suggest alternative approaches to a problem. A critical factor in guided discovery is that the learner remains in control, and that the teacher doesn't "take over" the activity.

Another model of teacher intervention that Groen (1981) suggests is that of the child as an experimenter and the teacher as research director. The idea is to put students into situations in which they can invent and try out hypotheses. Groen believes that in these situations the student will act in much the same way as a scientist or a mathematician. He states that "a scientist changes his mind only if he is aware of an anomaly. A mathematician changes his mind only if he is aware of a counterexample. A child will learn only if he extends the range of hypotheses he can generate and modifies or eliminates the transformations that lead to false ones. Thus it is part of the teachers' task to ensure that the child is aware of anomalies and counterexamples that result from his activities" (pp. 293).

Groen (1981) believes that under most circumstances it is very difficult for teachers to successfully carry off this type of intervention. It is difficult for the teachers to both identify the actual hyp[illegible]heses the student has invented, and to maintai[illegible] balance between the students' freedom and the cons[illegible]ints imposed by the intervention. Logo is seen as an [illegible]eal environment to support this type of interventi[illegible] because it is "naturally self-correcting." Groen states that "the counterexamples and anomalies are generated by the activity itself. This removes one of the most difficult aspects of Piagetian teaching: the need for the teacher to point out that there is something wrong with a child's hypotheses by means that do not interfere with the child's spontaneous activity" (pp.294). The activity of Logo objects, such as the movement of the turtle on the screen, makes it easier for the teacher to understand the students' intent. It also provides a student developed context in which to discuss counterexamples and anomalies.

Weir (1987) describes a model of teacher intervention in a Logo environment as the student working "with an expert as an apprentice and engaging in 'guided messing about', rather than receiving a pure diet of rules, principles, and concepts" (pp. 79). She believes that young children tend to learn naturally by "messing about", but through socialization they come to believe that they need to be taught. Logo is seen as an environment that is conducive to a mentor-apprentice approach, where the teacher can "contrive the 'messing about' to make it appropriate to particular kinds of experience and so to invite the desired learning" (pp. 79).

Collins, Brown, and Newman (1988) have developed a model for teaching and learning cognitive skills that they call a cognitive apprenticeship. While it is discussed in the context of teaching thinking and problem solving skills in reading, writing, and mathematics, they foresee future applications in computer environments. As it is, it closely parallels and serves as an apt model of teacher behavior in a Logo culture.

They describe traditional apprenticeship as focusing on specific methods of carrying out a task in a domain. Teacher activity can be described as a combination of modeling, coaching, and fading. Collins et al. (1988) state that "in this sequence of activities, the apprentice repeatedly observes the master executing (or modeling) the target process, which usually involves a number of different but interrelated subskills. The apprentice then attempts to execute the process with guidance and help from the master (i.e., coaching). A key aspect of coaching is the provision of scaffolding, which is the support, in the form of reminders and help, that the apprentice requires to approximate the entire composite of skills. Once the learner has a grasp of the target skill, the master reduces (or fades) his participation, providing only limited hints, refinements, and feedback to the learner, who practices the successively approximating smooth execution of the whole skill" (pp. 3).

This model of apprenticeship has usually been applied to physical processes and skills. In a cognitive apprenticeship the focus is still on learning through guided experience, but there is a shift to cognitive and metacognitive skills and processes. Physical skills and processes are easily observable, but cognitive and metacognitive ones are carried out internally and need to be externalized. To accomplish this, Collins et al. state that cognitive apprenticeship teaching methods should be "designed to bring these tacit processes into the open, where students can observe, enact, and practice them with help from the teacher and from other students" (pp. 4). Through activities such as discussion, modeling, practice, and group problem solving, the goal is to create a dialogue that externalizes higher order skills so that they can be gradually internalized.

Using a cognitive apprenticeship model in a Logo environment, the activities of the teacher will include:

Modeling

This involves the teacher carrying out all the tasks involved in a programming project so that students can observe and build a conceptual model of the processes that are required to accomplish it. The teacher must "externalize" his or her actions by creating a running commentary on all internal (cognitive) processes and activities.

Coaching

The teacher observes students in the process of programming and problem solving and offers help (when needed) in forms such as: reminding students of what they may already know, but have overlooked; introducing new information or strategies that can be directly applied to students' projects; or suggesting tasks that will require the use of skills in a different context.

Scaffolding

This involves the creation of support structures that will limit the amount of frustration and failure the students experience in the process of carrying out a programming project. Scaffolding includes the type of help the teacher provides in coaching, but it also involves the teacher in implementing (e.g., designing, programming, debugging) the parts of the student projects that they cannot yet manage. Accurate diagnosis of students' skill level is necessary so that they can assume as much of the responsibility for their project as possible as soon as possible. Again, the teacher has to make sure that he or she doesn't take over the project. The students and teacher work together in a collegial relationship, where the goal is a gradual ***fading*** of supports until the students are on their own.

Articulation

This involves all of the methods the teacher uses to get students to articulate their knowledge, thought processes, and problem solving strategies used in the process of programming. The methods can include teacher questioning (e.g., the Socratic dialogue), paired or group work where the student is required to explain or "justify" his or her actions, or requiring students to keep reflective journals related to their programming projects.

Comparison / Reflection

This involves creating situations that will enable students to compare their own programming / problem solving strategies with those of an expert (the teacher). An example is the teacher preforming a detailed "post-mortem" of the problem solving process involved in a programming project. The students can use the teachers' analysis for reflective comparison to their own projects / processes. The level of detail should vary depending on the students' current knowledge and skills, and should focus on those aspects of the process that will move the learner to the next level of complexity.

Structuring

Children often choose programming projects that are beyond their ability to successfully complete. In addition, they often focus on aspects of a microworld that offer little cognitive benefit, or on an area that they have already mastered. As with problem solving strategies, students also need to be exposed to exploration strategies. Exploring a microworld is something most students can do without teacher intervention, but it is not always done productively. Exploration as a teaching method comes with the fading of supports. When the students' cognitive and metacognitive skills reach a point where they engage in the problem solving process on their own, they should learn how to develop projects that are interesting to them and are within their range of capabilities. Early on, the teacher can structure student exploration by setting general goals and then encourage each student to focus on subgoals of interest to them. As the students acquire exploration skills they should be able to revise or set the general goals. The teacher's job is to help the students structure their explorations so that they are working up to, but not beyond, their capabilities. In doing this, they need to make sure the students maintain a sense of control and "ownership" of their own projects. Teaching becomes a mediational activity in helping the student move from inexperience and dependence to autonomy.

Weir (1987) stresses that with this type of learning the teacher needs to find a balance between maintaining general control of what goes on in the classroom, while locating control of any specific intellectual activity with the learner. To achieve this she calls for a "kind of coherent messing about." Students new to programming and to this type of exploratory learning cannot be expected to automatically provide the structure for their own explorations. A framework and learning environment must be created by the teacher that will support self-directed explorations. But, it should also be attuned to, and deal with, the possibility of floundering and frustration. It is obvious that this is not an easy task, even under the most ideal conditions.

Teaching for Transfer

A necessary component of explicit teaching is teaching for transfer. Learning a programming language is a necessary first step that enables students to engage in more cognitively demanding tasks. There is widespread agreement that in addition to gaining mastery of a programming language, students need to be introduced to both the cognitive strategies that can be used in a programming environment; and how these strategies can be generalized to other situations.

For example, Perkins and Martin (1986) found that "programming is a natural arena for the development of general cognitive skills ... [but] rather than expecting programming instruction of itself to boost cognitive strategies, one should teach cognitive strategies as part of better programming instruction" (pp. 227). Soloway (1986) believes that "the lack of impact of programming on problem solving may be due to the fact that students are not taught the key ideas underlying programming" (pp. 851). Shank (1984) states that programming "can and should teach logical reasoning. It is an important way to exercise the mind, but only if taught as such" (pp.202). Solomon and Perkins (1987) argue that for transfer from programming to occur, instruction needs to include a "significant press toward abstraction and reflection" (pp. 162). Sternberg (1984) contends that transfer across subject areas is not easily accomplished. He states that if learning is to transfer from one instance to another, it needs to be explicitly provided for. After reviewing the literature on transfer, Krasnor and Mitterer (1984) found that "transfer (if it occurs at all) would be expected between highly similar domains under circumstances where learners were fluent with the skills in question, had practiced those skills in several situations, and were explicitly aware of the general utility of the skills" (pp. 134). They go on to conclude that "it is possible that the overall instructional package offered by the Logo experience, blending as it does so many potent instructional devices in one curriculum, provides by far the best context for facilitating the learning and transfer of these powerful ideas" (pp. 141).

It is clear that the teacher has a crucial role in facilitating the transfer of problem solving skills in a programming environment. There seems to be a consensus that programming can be a uniquely suited vehicle for promoting higher order skills, but only when students are made aware of the aspects of programming they are likely to generalize to other disciplines.

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Enhancing instruction for Readers At-risk using Computer-Based Intervention Strategies: A review of selected software

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Introduction

As we enter the last decade of th' 'n century, the use of microcomputer-based lessons ..ppport of reading and writing instruction will continue to be a vital strategy for instructors of all age and grade levels. This is particularly true in the instruction of less-able readers—children who are at-risk due to various literacy dysfunctions. These include the inability to read at their grade or age expectation, a reluctance to write creatively, and/or a general lack of motivation for reading and writing. In providing remedial intervention for these students at the Bowling Green State University Reading Center in Bowling Green, Ohio, microcomputers are used to enhance reading and writing instruction. Specifically, clinical teachers use computers in the Macintosh family to provide a wide range of instruction targeted to the individual needs of students. Accordingly, this paper will describe a theoretical basis for using computers in writing instruction as well as a description of computer programs used in this instructional process.

Rationale for computer use

Instructional programs at the Bowling Green State University Reading Center are held on Saturday mornings. For ten weeks in a row, children come and spend 90-minutes working one-to-one with their clinicians. In using computers in these lessons, clinicians have a tool which can be highly motivational for the student. However, computers are more than just motivators at the center. Over the past two years, computer enhanced lessons have become a primary method of intervention at the Reading Center. This intervention follows a computer use model as proposed by Zeni (1990). Specifically, four aspects of instruction are emphasized in this clinical model. These include:

1. The production of short, meaningful pieces of writing,
2. The production of pieces which require revision,
3. Instruction which is social and collaborative
4. Instruction which results in quick, informal publication (p. 66).

These guidelines are applied in various forms. For example, computers are used to record students' dictations as applied in language experience activities. Computers are used to stimulate writing and reflection. And, computers are used to compose and publish stories and collections of student writing. Based on observations at the Center, it is apparent that these lessons have not only become a critical part of the program but aiso they have had a positive impact on student learning and motivation. Gomez (1987) cites five benefits of composing with computers. These include:

1. The ease of writing first drafts—giving attention to ideas.

2. The ease of revising first drafts.
3. The development of positive attitudes toward composing.
4. The ease of experimentation—that is, the ability to change fonts, margins, and style to meet the needs of various audiences.
5. The transition from writing to reader is made at a faster pace due to the ease in publishing (p. 241).

Software used

In order to provide this level of attention and intervention, writing software has been selected that will allow for maximum interaction and potential for learning. According to Zeni (1990), the selection of programs in developing computer based writing labs is critical. In selecting a word processing program, she suggests that the program have easy-to-remember commands and optional menus (p. 123). She also suggests that free standing desktop publishing and graphics programs be available for illustration of stories and book covers. Accordingly, in light of these recommendations, the following section describes the use of selected software at the Reading Center

In working with childrens' writing, *Microsoft Word 4.0* (Microsoft Corporation, 1987-1989) has become the standard word processor in the center. This program is used to record student dictated stories, to process narrative text for use with wordless picture books, and to compose pages of "big books" using Avery 8 1/2 x 11 labels. The primary features which make Microcsoft Word so useful include it's ability to personalize commands and menus, its spellcheck capability, the ability to compose in multi-column formats, and the ability to count words and sentences. By counting words and sentences in student dictation and writing, clinical teachers can easily collect evaluation data from student writing. Figure 1 illustrates a first grade student's story composed with *Microsoft Word 4.0.*

As stated previously, Zeni argues that initial writing lessons should incorporate short pieces of writing which result in quick and informal publication. In this regard, we have found that *The Print Shop* (Jochumson, 1986) is highly appropriate for this use. In the beginning, many "stories" written by children are short (three to five sentences in length). Using *The Print Shop*, the children can publish their stories complete with a border and graphic illustration without using different software. Further, the ease of mastering *The Print Shop* makes this program especially appropriate for teachers just learning to use the Macintosh. A sample graphic layout page, showing text composed by a fourth grade student, is shown in Figure 2.

A second series of software which enables the student to complete short writing passages and publish quickly is the *Once Upon a Time* series by Compu-Teach (Schafer,

My First Time at Disney World

First I went to my aunt and uncle's. Then I went to Disney World on a big bus. It took a long time.

First at Disney World I went to a 3-D movie. It was cool. There were things coming at me.

Next I went to A Small World After All. There were all these people dancing. There were all these countries like China. China was at the end.

Then I went on a boat ride. I saw crocodiles, real ones, but not on the boat ride.

I went to a place called the Tiki Room. It has birds and flowers singing.

That was the end at Disney World. I was too frightened to go on the pirate ride. I thought they were going to shoot me.

by Gary S.

Figure 1: A first grade student's story composed with Microsoft Word 4.0.

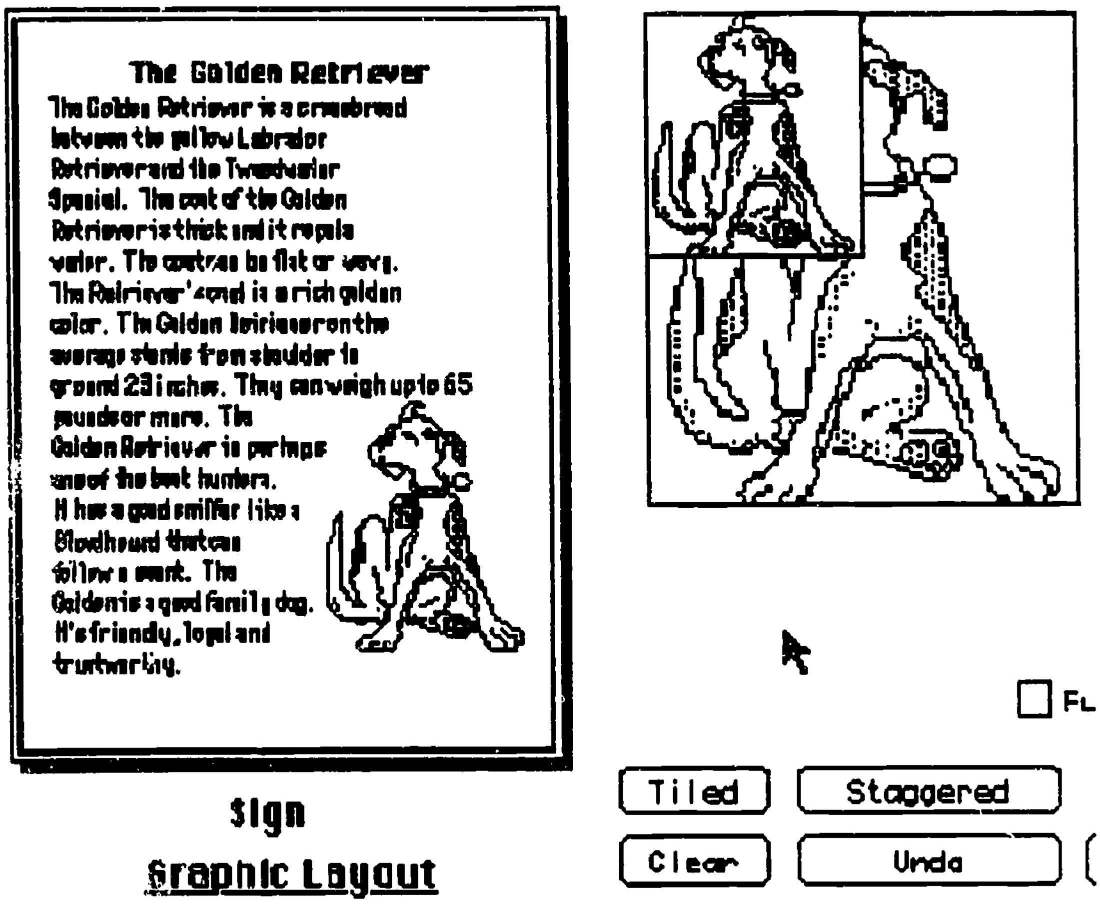

Figure 2. A sample graphic layout page from Print Shop showing a fourth grade student's text.

Kinder, & Professional Systems International, 1990). These programs (there are now three volumes) allow students to compose, design and publish illustrated stories. The illustrations are provided in three themes per volume. Included in each volume are three distinct backgrounds, and various figures that the child can place in the scene. These illustrations can be scaled to size, they can be rotated, and placed anywhere on the screen. Also, the newest versions of the program allow the student to record his/her reading of the story (on the Macintosh SI and LC). A sample page with illustration from *Once Upon a Time*, composed by the author, is presented in Figure 3.

For more elaborate book publishing or production of newsletters, *Ready,Set,Go 4.5a* (Letraset, 1988) is used. *Ready,Set,Go!* is especially appropriate for more sophisticated publishing when clip art or previously scanned student illustrations are to be incorporated into the text. Also, this program is useful in preparing special printing effects such as wrap around text. A section of a page from a fourth grade student's book composed with *Ready,Set,Go!* is presented in Figure 4.

Discussion

The software described in this paper are examples of products available for writing instruction. Their inclusion in this paper is in no way an endorsement that these are the only products which can be used to meet the instructional goals as presented in Zeni (1990). Other word processing or graphic illustration programs may be selected as local resources and expertise dictate. Likewise, these programs relate only to the Macintosh family. Other programs which fulfill the same applications are readily available in formats for the Apple II or IBM families. However, regardless of the computer used, the fact remains that computer processing of writen text can be a real benefit for at-risk students.

In summary, based on our experiences at the Bowling Green State University Reading Center, the following guidelines are proposed for those wishing to move into this area of instruction.

1. Start small. Don't try to create unit-sized lessons at first. As Zeni states, initial lessons should be short and meaningful.

2. Learn one program well before learning to use others. It is not necessary for teachers to become experts on a variety of writing programs in order to use computers in writing. Rather, a teacher could learn and use a single program, such as *The Print Shop* (Jochumson, 1986), in many effective applications.

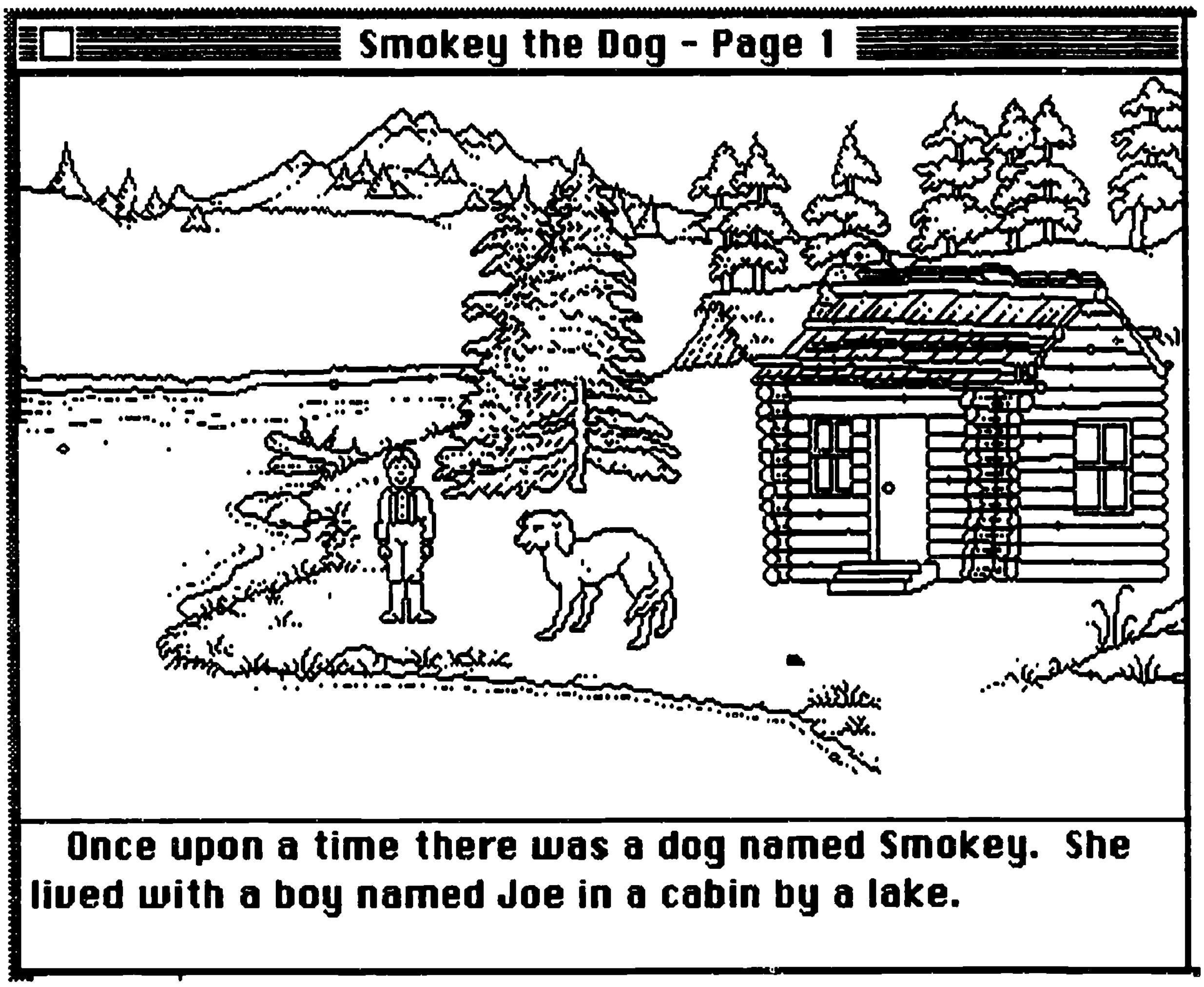

Figure 3. A sample page with illustration from *Once Upon a Time*, composed by the author.

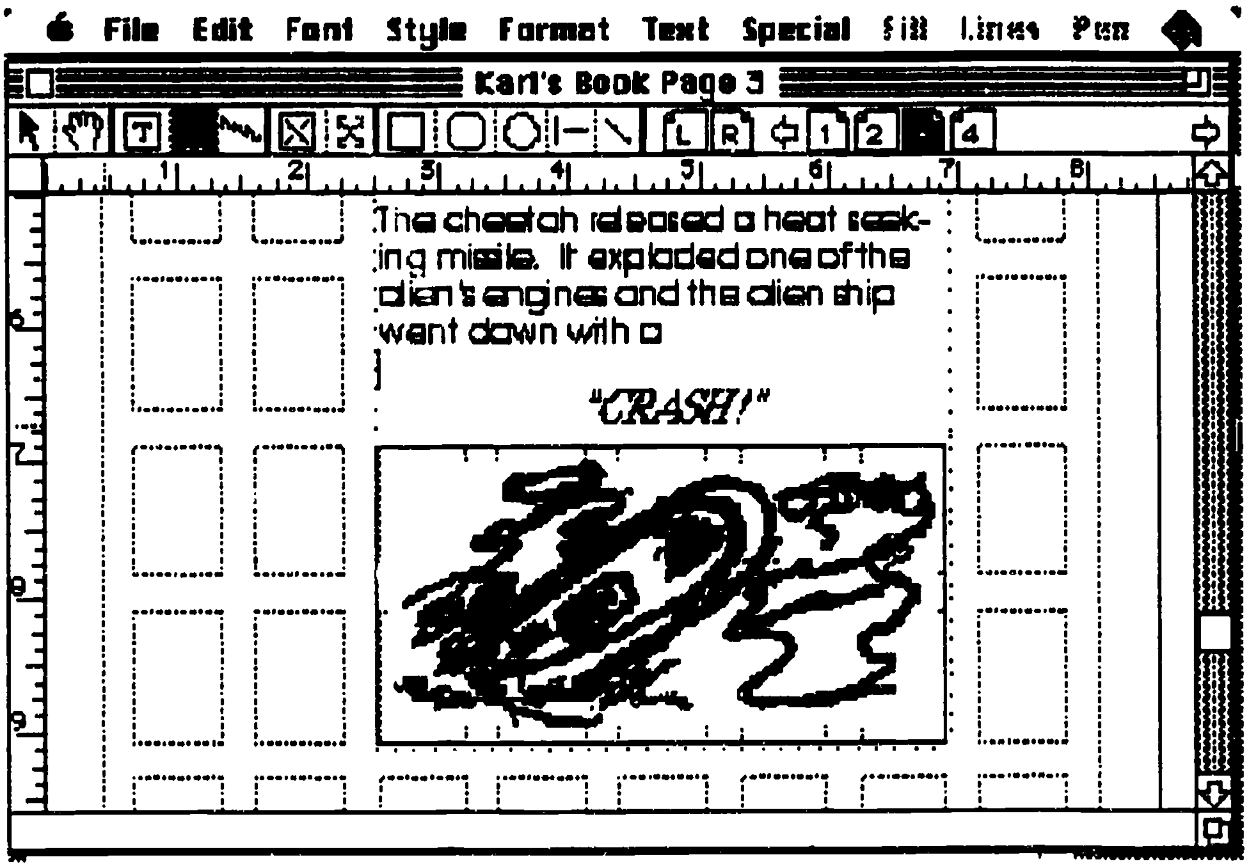

Figure 4. A section of a sample page from a fourth grade student's book composed with Ready, Set, Go, 4.5a.

3. Model the process for children. By showing students pieces of writing they have created, and using these as models, teachers can be sure students know what is expected in the writing activity.

4. Evaluate on meaning and process as well as form and mechanics. As Gomez (1987) states, initial lessons need to focused on meaning and thoughtfulness. The mechanics of the final piece can be addressed in revision and final editing.

5. Enjoy what you do. The use of a computer in the instruction of writing can be highly motivating for teachers and students. As teachers become more fluent in educational computing, true teaching enjoyment will follow.

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Teacher Posture in the Computing Environment

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Introduction

The numerous calls for school reform in the 1980s and advances in educational technologies have raised some important questions about the role of teachers and the task of teaching. Proponents of change insist that the classroom should become an environment in which students are active learners rather than passive receivers of information. Teachers' roles must change from that of information delivery to facilitation. Cooperative groups, interactive technologies, and resource rich environments must supplant the teacher-centered model in which all students attend to exactly the same material.

These reforms will require a substantial change in the posture of teachers, in strategies for motivating students, in methods of teaching, and in methods of evaluating student progress. Simply training teachers in new methods such as cooperative group work or in the use of new technological tools will not guarantee that change will occur. Some of the tacit assumptions that bear examination are: (1) teachers are willing to change their teaching styles to accommodate technology-supported environments; (2) preservice programs are ready to prepare teachers for these changes; and (3) people who select teaching as a career are *willing* to become facilitators of instruction.

Since a large number of schools already have computing facilities for their students, it has become possible to investigate at least one assumption in the change process: whether teachers do indeed change their posture from director to facilitator in a computer-rich environment. This paper describes a study of teacher behaviors in a computer classroom, defined as a classroom in which at least half of the students are using computers.

Research Questions

The question to be addressed by this study was, "Do teacher behaviors differ significantly in the computer-augmented classroom compared with the regular classroom?" The null hypothesis stated that no significant difference exists between teacher behaviors in the two settings.

Questions related to differences in teacher behaviors included:

1) If teacher behaviors differ in the computer-augmented classroom, which specific behaviors vary?
2) What are the dominant behaviors in the two settings?
3) How much time do teachers spend interacting with individual students in each setting?
4) How much of the teacher's time is spent on instructional matters?

Method

In order to answer these questions, we observed 16 teachers in both the regular classroom setting and in computer-augmented classrooms such as a computer lab. The behaviors observed included:

- teacher questions (whole class and individual);
- answering questions; providing feedback;
- giving procedural instructions;
- providing information;
- listening;
- writing (on chalkboard or paper);
- moving about the room;
- attending to student behavior;
- making statements related to content (lecturing, explaining, clarifying, both to the whole class and to individuals);
- making statements unrelated to content (asides, comments, opinions);
- operating equipment or tools (manipulatives, computers, peripherals);
- reading (from a book, chalkboard, transparency);
- attending to administrative details not related to the instruction;
- watching (students, computers); and
- non-attending behaviors (grading papers, leaving the room, talking with a visitor).

The various behaviors were observed at equal time intervals, a variation of of the Timeline Coding technique (Acheson and Gall, 1980).. For example, every five seconds, the observer would note the type of behavior observed. The data were later tallied and recorded as percentage scores. The resulting 15 scores then revealed proportions of time spent during the observed class in each behavior category. Two sets of data were collected for each of the 16 participants: one set in the regular classroom and one set in the computer-augmented classroom.

Results

Descriptive Statistics

Tables 1 and 2 list the medians and standard deviations for each behavior observed, measured in percentages of class time. Summary data indicate that teachers spend an average of 72 percent of regular classroom time on instructional activities, not including such behaviors as attending to discipline, moving around, writing and reading, attending to administrative matters, and attending to matters outside of the instructional situation. In the computer-augmented classroom, this percentage decreases to approximately 67%. This decrease is not significant, but can be explained by the assumption that students are attentive to computer operation and the teacher uses this so-called freedom to attend to non-instructional matters.

Tables 1 and 2 also reveal that, of the behaviors observed in the classroom, 36 percent of the teacher's time was spent interacting with individual students.

Table 1
Means and Standard Deviations for Percentages of Time Teacher Behaviors Were Observed in the Regular Classroom

Behavior	Mean	Standard Deviation
answering questions	3.1	2.7
comments unrelated to instruction	2.1	2.5
attending to discipline	4.9	3.5
providing feedback	3.6	2.9
giving procedural instructions	16	8.1
listening	12.7	9.8
moving about the room	7.7	5.2
writing	2.9	4.7
operating equipment/manipulatives	2.1	2.9
questioning	16.6	14.5
reading	4.7	8.3
non-instructional administration	3.9	5.6
content-related comments/lecture	12.8	9.5
watching	2.9	2.6
non-attending	2.0	11.8
Summaries:		
instructional activities	72.2	12.8
interaction with individual students	36.1	13.0

Table 2
Means and Standard Deviations for Percentages of Time Teacher Behaviors Were Observed in the Computer-Augmented Classroom

Behavior	Mean		Standard Deviation
answering questions	1.8	(-)	2.6
comments unrelated to instruction	1.1	(-)	1.1
attending to discipline	4.6	(-)	4.7
providing feedback	2.1	(-)	3.3
giving procedural instructions	11.8	(-)	10.3
listening	6.9	(-)	5.4
moving about the room	13.4	(+)	8.3
writing	0.3	(-)	0.8
operating equipment/manipulatives	8.8	(+)	6.8
questioning	9.1	(-)	8.9
reading	2.1	(-)	2.4
non-instructional administration	5.9	(+)	8.0
content-related comments/lecture	14.8	(+)	11.6
watching	12.0	(+)	10.2
non-attending	6.0	(+)	8.8
Summaries:			
instructional activities	66.6	(-)	14.2
interaction with individual students	34.9	(-)	17.2

+ or - indicates whether the behavior is increased or decreased when compared with the regular classroom

Specifically, these behaviors included questioning students, answering students' questions, providing feedback, correcting student behavior, providing individual procedural instructions, listening to a student's comments or reading, and giving students information on lesson content. In the computer-augmented classroom, this behavior decreased slightly to 35 percent of the time.

Correlations

A set of correlations among teacher behaviors were obtained first to get an idea of whether the behaviors observed were typical of the sample. Most distributions of teacher behavior were highly and significantly correlated to the distributions for the rest of the sample. A clear exception stood out. An examination of the raw data on this teacher indicated an atypical pattern of behavior. First, in the regular classroom, this teacher spent a high percentage of the time (34%) reading to students from a book. This was the only instance in which this activity was observed. Second, this teacher's behavior in the computer laboratory differed from most of the other observations. While most teachers moved around the computer room, watching students work, answering and asking questions, providing assistance, and giving feedback, this teacher sat at the front desk and graded papers or watched students' behavior from her seat. Watching and non-attending behaviors totaled 60 percent of the time.

The next analysis was performed on distributions of behaviors in the regular classroom and the computer-augmented classroom. Significant correlations were found for four of the fifteen variables. These are listed in Table 3.

Measures of correlation between classroom and computer room behaviors for individual teachers were needed to answer the main question of the study. Nine subjects showed a significant ($p<.05$) positive correlation between two sets of behaviors; four analyses resulted in negative correlations; and two sets showed a positive correlation, though the results were not significant at the .05 level.

In an effort to identify behaviors that might be related to providing individualized attention to students, a correlation test was applied to the summary statistic and the individual behaviors. A correlation was found between providing individualized attention in the computer-augmented classroom and verbalizing behavior (lecturing, giving information on content, discussing lesson material): $r = .60$; $p = .01$.

Discussion of Results

On the average, teachers appear to spend the bulk of their classroom time giving verbal instructions on content and procedural instructions (such as how to operate computer software, measure angles, or takes notes). They also spend time on questioning and listening to students. In the computer-augmented classroom, less time is spent listening, but more time is spent watching student performance and computer screens. Teachers spend slightly more time in the regular classroom on instructional activities and interacting with individual students.

Correlational analyses reveal that teachers who spend the most time asking and answering questions in the regular classroom are also most likely to spend time doing so in the computer-augmented classroom; conversely, teachers who spend little time on these activities appear to do so less in the computer-augmented classroom as well. Thus, for these four behaviors, the null hypothesis cannot be rejected: behavior in the regular classroom can be said to be predictive of behavior in the computer-augmented classroom.

For sixteen subjects in the sample, no appropriate generalization exists as to whether teacher behavior is consistent in spite of setting. However, in this study, a majority of teachers exhibited computer room behaviors highly correlated to those of the classroom. The null hypothesis cannot be rejected.

We must be particularly cautious in interpreting the results of these findings. If a teacher's observed behaviors are highly consistent between the classroom and computer room settings, we cannot assume that the teacher is *not* capable of facilitating in the classroom. The teacher may actually be using facilitative, individualized strategies in both settings. Data on one of the nine teachers who showed this consistency of behavior reveal that her interactions with individual students are above average in both settings; thus, we can suspect that one of the nine teachers is a facilitator in both settings.

The findings that are of particular interest are those that either substantiate or contradict some of the assumptions in the popular literature on teacher behaviors in the computer-augmented environment. Assumptions that teachers spend more time moving about the room, interacting with individual students, asking more questions, and providing reinforcement and feedback are unfounded within the results of this study. Some facilitative behaviors remain unchanged in the different settings.

The research team made notes of observations and events that were of interest in this study. One observer noted that she had assumed that frequent movement among students was desirable, particularly in the computer-augmented classroom. However, extremes of such behavior appear counter-productive. One teacher moved about the room so frequently that she spent almost 20 percent of her time dashing from one end of the room to the other, and this was time that was taken away from interacting directly with students. Half of the teachers in the sample spent more than 10 percent of their time moving around, with one teacher spending almost 36 percent of lab time in movement. This does not include the time in which she stopped to watch what students were doing.

We also wondered whether we would see a decrease in time spent on disciplinary matters. Some teachers cut down their disciplinary statements in the computer lab by half, and one teacher who spent 10 percent of classroom time correcting students made no disciplinary remarks in the computer-augmented classroom. Conversely, one of the teachers increased the disciplinary time from approximately 4 percent to 17 percent in the computer-augmented classroom. These examples help to explain why no significant correlation was found between behaviors in the two settings for eleven of the fifteen variables studied.

We could not easily explain the correlation between

Table 3
Regular Classroom Behaviors Significantly Correlated to Computer-Augmented Classroom Behaviors

Behavior	r*	p**
answering student questions	.58	.017
providing procedural instructions	.75	.0012
listening	.60	.014
questioning	.72	.002

* Pearson product moment correlation coefficient

** level of significance

verbal behaviors and individual student interactions in the computer classroom, except to propose that teachers who interact frequently with students do so for the purpose of providing information. We observed many instances in which the teacher stopped to discuss the content with students or provided verbal information to the whole class before beginning the computer activity. An examination of the raw data on five teachers who had higher than average individual interactions *and* higher than average verbalizing revealed that four of the five also were above average in listening time.

Implications

The study hypothesizes that no significant difference exists between the two environments. Since we have little evidence to reject this hypothesis for most teacher behaviors, then teacher preservice and inservice programs must address the role of the teacher as facilitator if such a change is to occur. Facilitative behaviors such as questioning, individual interaction with students, watching or monitoring student progress, and listening to students' observations and comments will not automatically occur because students are working with computers. In the case of questioning, providing procedural instructions, and listening to students, these behaviors appear to match the behavior that already existed in the classroom.

Further study will continue to analyze a wider sample of teachers. This study also provided rich student behavior data. These will be the focus of another report. An experimental study is also called for that provides a substantial intervention and measures the increase of facilitative behaviors as a result of the intervention.

This study represents a modest beginning in gathering objective data to inform educators whether we can, in fact, expect changes in education as result of technology use. Clearly, our preservice and inservice programs must address these issues directly and prepare teachers to meet the challenges of the technology-infused curriculum.

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THEORY

Concern over teachers' preparation for using computers has been understandable. Amid growing national appreciation of students' need to use technology for their studies and future work situations, we read pessimistic reports about the poor integration, or lack of integration, of computers into the school curriculum.

While this concern has been evident since microcomputers began to be introduced into schools, the proliferation of available hardware and software has made the situation more serious and has, in turn, called forth a host of technology-related courses and projects in schools, colleges, and departments of education.

The number of teacher education efforts in technology has by now reached such a critical mass that a hard look at their underlying bases and assumptions is in order. When developing courses or workshops for teachers in this area, the first aspect usually tackled is *what* to teach prospective teachers about computers—what hardware, what software, what areas of the curriculum the computer applications cover. A second aspect is *how* to teach it—what pedagogical methods to use, how to integrate technology into course teaching—although in some cases the how is neglected for the what.

A critical, third area to consider might be called the *why*—why is it important for teachers to learn what is included in a given course? Why is it necessary for teachers to learn about computers at all? What goals for students are we trying to promote? How will what a course covers achieve our goals? What theoretical assumptions about learning and teaching guide our course development? Questions like these form the background to, and the rationale for, computer education. They are the subject of this section.

Whether or not teachers (or teacher educators) realize it, every course has underlying theoretical bases, conceptual frameworks, and/or assumptions about how individuals learn, what they should be learning, and why such learning is important for them. Lecturing to a class, for example, carries with it an assumption that people will, in some satisfactory way, learn from such teaching. Technology offers new potentials for learning and teaching, but at the same time it poses new questions: Is what we do with technology similar to what we did before? Does technology have implications for how people learn, for how school should be structured, for the role of students and teachers? Do we need to rethink our fundamental assumptions about teaching to make the best use of technology?

The authors represented in this section are all concerned in some way with clarifying the theoretical base of what and how teachers should learn about technology. The papers are diverse because the situation is complex: in developing courses for teachers we cannot consider the what, the how, and the why as separate aspects; rather,

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they are all parts of the same problem and must ultimately combine to create a coherent learning situation.

A set of common themes runs through this section. *First*, the authors of the papers included in this section argue the importance of reflecting on how teachers learn, and how technology may change the way they learn. *Second*, they present a view of teachers (and other adults) as lifelong learners, an idea that technology has made us more aware of. *Third* is the importance of providing teachers with the opportunity to model, in their own learning, ways they want their students to learn. *Fourth*, and closely related to this last theme, learning should be participatory and should involve solving problems that are realistic and meaningful. Several authors argue that technology has made this kind of learning more attainable. *Fifth*, many of the papers are concerned with connection between theory and practice. *Last*, the papers as a whole emphasize the notion that teachers should reflect critically on their practice, and that such reflection should be informed by knowledge as well as experience.

Focusing on how teachers or prospective teachers learn about computers, two of the papers suggest the use of analogies to promote conceptual understanding. Reminding us that learning about computers is still a new area of study, one which most adults have little background in, papers by George Bright and Jerry Galloway argue that the effective use of analogies can enhance understanding of new concepts by connecting them to situations already familiar to students. They further argue that present computer courses and texts need much improvement in this area.

Other papers expand on the nature of learning about computers. Esther Javetz suggests that courses should be organized conceptually to promote understanding. She suggests that this approach would be more effective than the common procedural approach which has students learn lists of steps to follow to make computer applications work. Gene Sullivan discusses the case study method of presenting problem solving experiences for students, a technique that has long been used in medicine, law and business, and more recently in education. Computers, Sullivan argues, add to case studies by offering immediate feedback and interactivity.

Helen Harrington examines theories of adult development as a basis for teacher development, arguing that critical inquiry is closely related to development. We need to plan for prospective teachers' conceptual, epistemological, and professional development. Prospective teachers need to know about schools, teaching and learning in a variety of ways and from a variety of perspectives. Several computer assisted activities described here provide students with opportunities for role taking, concept mapping, and practical reasoning which may, in turn, facilitate development.

One of the applications described by Harrington is discussed in detail by David Bair and David Anderson. Diverse Perspective on Education is a simulation in which students play (and trade) roles of teachers and educational consultants as they collaboratively work through case studies based on problem situations in education. Through such work students reflect on, and develop an openness to diverse perspectives, and critically connect their learning to their own field experiences.

Todd Hoover, Jeanette Mines, and Lucia Gagnon focus on ways in which computer related activities can be used to help prospective teachers begin to reflect on action. They suggest that using an Instructional Verbal Analysis System helps prospective teachers begin to develop the skills in self-assessment that contribute to more effective teaching behaviors. They caution though, as other authors do, that technology, in and of itself, will not improve teacher learning. It is the thoughtful application of technologically-based activities that contribute most to learning.

Marsha Davis describes a summer program in which teachers are actively and collaboratively involved in learning about math — especially statistics. Based on the theory that learners construct their own ideas rather than passively absorbing others, teachers in this program work with mathematical software which enables them to manipulate mathematic objects. Computers, according to Davis, facilitate the presentation of more complex, and thus more realistic, mathematic and statistical problem situations for students.

Suzan Yessayan presents a study of faculty adaptations to using microcomputers and discusses stages in the process of adopting this innovation. Based on this study, she suggests a set of principles that should guide training programs to help teachers build their formative experiences over time.

Not only are computers still relativley new to teachers, we are still in a beginning stage of considering the kinds of uses to which they can and should be put. One area of use which teachers are starting to adopt is cooperative learning. Howard Budin argues that, to connect computers effectively to collaborative work, teachers need a solid background in how technology has effected ideas about cooperative and individualistic activity. He further suggests that teachers should be provided with the opportunity to model principles of cooperative learning with several kinds of computer applications.

Each of the papers presented here reflects the potential technology offers for facilitating the learning of prospective teachers and their future students. But, perhaps, more importantly, they present technology as a tool that can provide students of teaching with new ways of learning—ways of learning that will enhance their professional effectiveness.

Analogies in Computer Literacy and Computer Science Textbooks

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One of the important tasks of teachers is to explain new information to students. One long-accepted technique for explaining is the use of analogies to help students tie the new information to previously learned information. Learning theorists have long recognized the need for making such connections, and recently those who believe that students construct the knowledge that they learn have emphasized the need to understand the relationship between (a) teachers' explanations and (b) what students actually hear and then accommodate into their cognition (e.g., Wachsmuth & Lorenz, 1987). There is evidence that even in short term instruction, analogies can enhance the effectiveness of initial instruction as well as the retention of information (e.g., Halpern, 1987).

Interviews with students across content have revealed that students do not construct information in the ways that are generally considered "correct" (e.g., Galloway, 1987; Osborne & Freyberg, 1985). No one, however, seems to have studied the analogies that are provided in published textbooks. Without adequate modeling of how to use analogies effectively in instruction, such as might be provided by textbooks, teachers are not likely to incorporate analogies into their teaching.

All teachers who are expected to use computers in teaching students who are novices at dealing the technology need to have expertise about analogies that can potentially help those students make effective use of the technology. Teacher educators must take on the responsibility of knowing what analogies are available to present to teachers and to be ready to use those analogies any time technology is used with teachers.

Teachers have typically not been forced to think carefully about ways to teach computer concepts; their only models for teaching were most likely instructors in university content courses. University instructors stereotypically give lectures about content with little concern about relating that information to students' previous knowledge. Thus, the main source for teachers to see how to use analogies to improve their students' learning is likely to be the textbook itself or the teacher's guide that accompanies the textbook. Unfortunately, we know little about the kinds of analogies that appear in such books. This analysis was designed to alleviate that problem by cataloging the analogies that appear in computer literacy and computer science textbooks.

Previous Studies of Analogies in Computer Education

A global analysis of textbooks for the first computer science course (TenEyck, 1988) revealed the use of almost no analogies. Analogies were not the primary focus of that analysis, however, so an unanswered question was whether a more careful analysis might reveal implicit use of analogies.

Galloway (1987) in an interview study examined the analogies used by university computer literacy students in explaining their understanding of computing concepts. He found that they used only one analogy, namely, that of a typewriter for a word processing program. This appeared to have been the only analogy used by the course instructor, suggesting that students may assimilate analogies into their cognitive structures if given a chance, even though they might not be able to generate analogies spontaneously. It certainly seems reasonable to assume that a necessary condition for students' using analogies is the existence of analogies in textbooks or in the instruction given by teachers, but it is doubtful that such use will also prove to be sufficient.

Method and Results

In Texas there are five textbooks adopted for computer literacy in middle school and four textbooks for each of the computer science courses in high school. In addition the textbook for the required undergraduate textbook for preservice teachers at the University of Houston was considered as part of the pool of textbooks for consideration. From among these 14 books, five books (listed below) were examined to find the analogies used to explain fundamental computing concepts and ideas. Each book was examined, page by page, to find the analogies that were used. The first two are for middle school, the third is for university, and the last two are for Advanced Placement computer science.

1. Dublin, P., & Kelman, P. (1986). *Macmillan Computer Literacy*. New York: Macmillan.

2. Luehrmann, A., & Peckham, H. (1986). *Computer Literacy: A Hands-on Approach*. New York: McGraw-Hill.

3. Sullivan, D. R., Lewis, T. G., & Cook, C. R. (1986). *Using Computers Today*. Boston: Houghton Mifflin.

4. Mandell, S. L., & Mandell, C. J. (1986). *Computer Science with Pascal for Advanced Placement Students*. St. Paul, MN: West Publishing.

5. Naps, T. L., & Singh, B. (1986). *Introduction to Data Structures with Pascal*. St. Paul, MN: West Publishing.

Of course each of the books used standard computer terminology (e.g., bug, hacker, pirate) that may call up analogies to ordinary events and objects. However, these were not classed as analogies, since they are part of the jargon of the subject. The text surrounding introduction of these terms was searched for explicit analogies, but mere use of the terms was not counted.

In two of the books (Luehrmann & Peckham, 1986; Naps & Singh, 1986) no analogies were found at all. Luehrmann and Peckham seems based on the assumption that simply learning how to use a computer is adequate for development of computer literacy; it does not seem important to the authors to develop cognitive frameworks for underlying concepts. Naps and Singh is a text for Computer Science II, so the authors may have assumed that students had already developed adequate cognitive frameworks for the content.

In Dublin and Kelman (1986) only two analogies were found. The first was in the introduction; it was a 'historical' view (p. 3) that "Some people thought computers were like giant brains that might take over the world." The second was in a lesson review (p. 52); "How was the development of the microcomputer like Gutenberg's invention of the printing press?"

Five instances of analogies were found in Mandell and Mandell (1986). One was a general comparison of top-down design to making a pizza. "For example, in making a pizza, the first question was not how much flour needed to be used in the dough. This question would not be taken up until the subtask of making the dough was actually undertaken" (p. 31). The other analogies (Figure 1) were made along with the introduction of new terms. The last two examples in that list begin to make explicit how the analogies are like the computing concept with which it is being compared.

Figure 1. Short Analogies in Mandell and Mandell (1986)

Most mainframes are manufactured as a "family" of computers. (p. 3)

Computer storage can be compared with a long row of mailboxes. (p. 44)

A good analogy for a stack is a pile of trays in a cafeteria. When you want a tray you take it off the top of the stack. When you are finished with the tray you put it back on the top. (p. 330)

A good analogy [for a queue] is a line of people at the movie theater. As people are admitted from one end, people are added to the other. The first person in is always the first person out. (p. 332)

Sullivan, Lewis, and Cook (1986) were by far more prolific in their use of analogies (Figures 2 and 3).

Almost all instances, however, were found in the first 100 pages of the 528-page text, with most of even these appearing in the first 21 pages. There is no clear theme to the analogies in Figure 2; rather there is a mixture of human and object analogies.

Six of the analogies (Figure 3, next page), however, are very well developed, with similarities and differences made explicit for the reader. These analogies are significant because there are careful parallels drawn between the similarities and differences of the computer concepts and the objects/events used for comparison. Having such clear parallels ought to improve students' skill at least at recalling the essential ideas.

Discussion

Many of the analogies can be classed as "simple instructional analogies;" that is, analogies presented in a single statement (e.g., an X is like a Y) as if the students will all be able to draw appropriate contrasts and comparisons with the underlying computing concepts. The simple analogies scattered through the second 50 pages of Sullivan et al., for example, seem to have been "thrown in" because they were convenient rather than because of their special significance in helping to communicate the information. The strength of this approach is that effective teachers will use these analogies as a springboard for discussion, even though they might not have thought of the analogies on their own. The weakness is that without a careful comparison of the analogies to the underlying concepts students might draw the wrong comparisons and may actually learn concepts inaccurately. In part the learning of misconceptions may be attributed to the mixed signals received from a series of analogies appearing close together in a textbook. A mixture of human and mechanical references, for example, might actually confuse more than illuminate the ideas.

The analogies that are more fully developed can be classed as "instructional analogy comparisons;" that is, analogies for which similarities and differences are explicitly presented. Both similarities and differences are important if students are to know when to draw on a particular analogy and when to ignore it. Because students are novices with this information, they are not likely to be able to identify those similarities and differences themselves. The six developed analogies of Sullivan et al. fall into this class, and can serve as models for ways that analogies need to be developed in order to be effective teaching devices. Mandell and Mandell's analogies for stack and queue are simpler versions, but they lack any detailing of how the analogy is not like the concept being discussed. In the same way, Dublin and Kelman's lesson review question asked students to find similarities but not differences. If students walk away from an analogy believing that the analogy is like the concept in all respects, students are likely to overgeneralize and thus to try to apply the concept inappropriately. Inappropriate generalization seems responsible for many misconceptions that students develop.

Using a computer is literally child's play if you have the right program. (p. 8)

The traditional view of a computer is that it is a "mathematical brain." (p. 9)

The computer was like a fast adding machine. (p. 10)

Computers can "talk" to each other and to people over the telephone line - using computers at both ends. (p. 12, figure caption)

Like a television network, they [computers] provide valuable and important services in bulk. (p. 13)

For automobiles a steering wheel has been found to be the best "input device." (p. 66)

A monitor is basically a high-resolution television set that has been stripped of the speaker, channel selector, and radio-frequency receiver. (p. 84)

Think of the supervisor [kernel] as a traffic cop who signals when each activity is permitted to take place. (p. 98)

Figure 2. Short Analogies in Sullivan, Lewis, and Cook (1986)

If a computer were a component stereo system, we might imagine the music to be the software and the record player to be the hardware. In a stereo system, information is recorded on the surface of a platter, entered into the stereo through a stylus or needle, and sent to the speakers to be converted to sound. In a computer system, information is recorded on the surface of magnetic tape, magnetic disks, and other devices; it is entered through a keyboard or some other special equipment attached to the computer; and it is sent to a display screen or another device designed to accept electrical signals and convert them into human-readable form. A printer, for example, converts electrical signals into intelligible text. Figure 1.12 show the similarity between a stereo and a computer system. Both systems receive some type of input, process it, and then produce some kind of output.

Despite these similarities, computer systems differ in a significant way from stereos or any other kind of mechanical system. Every time a particular record is played, the stereo system repeats exactly the same tune; it can play whatever is on the record but cannot create new music. In contrast a computer system can produce different and possibly surprising results each time it is run. It is the software of a computer system that provides the "intelligence" for a computer system to "play back" a different "tune." Thus software is the "mind" of a machine, whereas hardware is the "body." Without the mind the body does not know what to do. (pp. 16-17)

To illustrate how timeshared mainframes and minicomputers give the illusion of simultaneous use, consider how a juggler appears to toss three balls into the air at the same time. A juggler actually holds only one ball at a time; but while one ball is in the left hand, another ball is in the air between hands, and the third ball is in the air above both hands. Each ball is given a turn to be tossed into the air. Most of the time the juggler is doing nothing!

A timesharing computer system juggles programs by keeping all but one "in the air." Only one program is ever running at any time; but because the computer is so fast, you never notice that each program spends most of its time waiting to be "tossed in the air" by the CPU. The CPU serves each program in "round robin" fashion, just as the juggler tosses each ball, one after the other, returning to the first ball to repeat the process. (p. 21)

Memory is divided into a large number of storage cells. We can think of them as somewhat like the safety deposit boxes on a a bank vault wall, or as post office boxes, as shown in Figure 2.3. Each box or cell has its own unique electronic address - a number identifying its location - and each is the same size. However, unlike a post office box, locations in computer memory can hold only numbers. (p. 36)

Making copies of your work on a disk (and on paper) is like buying an insurance policy: usually you don't need it; but when you do, it pays off handsomely. (p. 161)

A computer-based DBMS system in some ways resembles a public library where people can share documents such as books, magazines, films, and newspapers. Access to the thousands of documents is possible because the books are catalogued in a logical way, such as with the Dewey Decimal system or the Library of Congress system. It's easier to retrieve a document by using a catalog than by simply browsing through the entire library, because card catalogs provide a standard way of accessing information. If we use the terminology of database management systems to describe a public library, we would call the entire collection of documents the database and the dictionary and card catalog the logical schema. (p. 286)

To understand the difference between compiling a program and interpreting it, consider two ways for an American to translate a document in French into an English speech. Using the compiler method, the American speaker converts the entire French document into an English document before giving the speech. Using the interpreting method, the American converts the French document into English while giving the speech (see Figure 15.1). This removes the need for creating an intermediate English document, but the speaker must convert the French document in English each time it is presented. (p. 446)

Figure 3. Developed Analogies in Sullivan, Lewis, and Cook (1986)

Conclusions

Analogies clearly do not appear very often in published computer literacy and computer science textbooks. This is disappointing, since research suggests that learning might be improved through analogy use. The lack of analogies in textbooks may be driven by the expectation of textbook authors that teachers can "fill in the gaps," though my own experience working with teachers would argue that such an assumption is unwarranted. Computer teachers need models for what analogies to use as well as for how and when to use them.

Analogies seem logically to be most effective if they are used when a concept is introduced. Mandell and Mandell's analogies for stack and queue are nice examples of this, though more explicit comparisons would have been better. However, if an analogy is used only at the point when the definition is made and is not referred to again, students are not likely to learn how to use analogies as a metacognitive device for learning. Students, as well as teachers, need to see models of how analogies can be used to support the development and elaboration of ideas. Indeed better conceptualized research on continuing use of analogies in instruction needs to be conducted.

Finally, this analysis raises some suggestions for experimental investigations that might be conducted. First, do analogies improve learning? More specifically, do analogies for "static" concepts like stack have a greater impact than analogies for "dynamic" concepts like top-down design. Second, what kind of discussion in class is helpful for improving the effectiveness of analogies? Is peer discussion and elaboration of analogies more effective than teacher discussion? Third, what effect does elaboration of differences between the concept and the analogy have on student performance? On students' future use of the analogy? On appropriate application of the concept? Fourth, how well do students remember the analogies? Is remembering analogies correlated with remembering the concepts?

Understanding methods for teaching computing concepts is an area in which little is understood. Computer science and computer literacy are relatively new additions to the school curriculum, so we have little experience on which to base judgments. However, the importance of the ideas makes study of such methods an area with rich payoff for student learning. Analogies ought to play a more critical role in this area than in other disciplines because of the universality of applications of computing concepts and because of the lack of formal school based instructional prerequisites. Teachers will have to rely on what students bring with them to computer classes from the real world rather than from previous course taking.

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Analogies in Educational Computing: An Instructional Strategy

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Preservice teachers suffer from misconceptions and erroneous notions about computing, even after computer literacy education. In addition to such misconceptions it has been discovered that students also have difficulty explaining computing as they attempt to account computing rituals and procedures (Galloway, 1990). Mawby, Clement, Pea and Hawkins (1984) identified the fundamental misconceptions, limited understandings, and inept explanations students have that can have a significant effect, not only on their use of computers when they begin teaching, but on their students' understanding and use of technology as well. It was shown that, in spite of clearly understanding the relationships between human thinking and computer operation, students had misconceptions, confusion, and weak mental models about computing.

The inadequacy of mere rituals, without a deeper conceptual understanding, is discussed by Perkins and Simmons (1988). They identify ritual learning as limited to procedural knowledge and lacking in true expertise. Kintsch and Greeno's (1985) work with arithmetic word problems supports the relationship between conceptual understanding and problem solving. The importance of sound conceptual models in problem-solving and higher-order thinking is further supported by Mayer, Bayman, and Dyck (1987).

The use of analogies can be an extremely helpful tool in learning new concepts. Analogies can help students resolve conflicts between new information and previous concepts. Fully explored analogies involve a detailed comparison of relationships. This comparison has been described as "the core of analytical reasoning," (Whimbey & Lochhead, 1984, p. 19). The organization and internal representation of information is crucial in problem solving (Kintsch & Greeno, 1985). "If analogies speed the formation of differentiated schemata, then comprehension and solution of the problem should be facilitated," (Halpern, 1987, p. 80).

Hobbs and Perkins (1985), in addressing the development of computing students' mental models, suggest the use of analogies "instead of a literal account" (p. 5) will facilitate the development of important concepts. Mayer, et al., (1987) account for improved learning from direct instruction on mental models for beginning programmers. General content in computer literacy or educational computing is another area in which analogies should be particularly effective in building better mental models and improved concepts (Galloway & Bright, 1990).

An analogy maps the relationships between two domains (Greeno, 1983). One domain should be familiar to the learner. This serves as the vehicle for understanding the target domain. Figure 1 illustrates how relationships (A-B, C-D) in Comparison Domain 1 can be related to relationships in the Target Domain. All things being equal, Comparison Domain 2 would serve as a better analogy because the third comparable relationship (E-F) provides a bit more extensive and useful mapping for understanding the target domain.

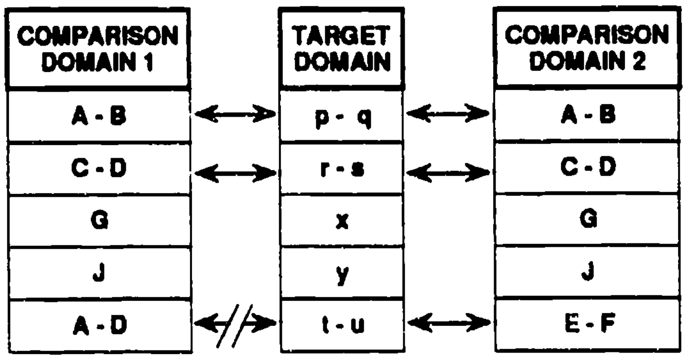

Figure 1.

While one may see a given concept as highly analogous to another, analogies, in serving the learning process, are highly individualistic. For example in Figure 1, if Domain 2 is not familiar to the learner compared with Domain 1 then Domain 1 might serve better in the learning process — in spite of being less similar.

Halpern (1987) illustrates this point by referring to the use of the concept of the solar system to help students understand the structure of an atom. If one knows nothing about the solar system then the analogy is useless. However, one can often think of several analogies for a given concept. For example, a possible alternative to Halpern's analogy above might simply be the swinging a ball in a circular motion at the end of a string.

Analogies vary in their usefulness in the learning process both because of the existing knowledge of the learner and also because analogies can vary in the similarity of their relationships to the target concept. Gentner (1983) speaks of the essence of an analogy being more than just a list of attributes in common; it is a shared structure of relationships between the two domains. In fact, attribute similarity or lack of similarity (e.g., attributes G, J, x, y, M, & N in Figure 1) neither contributes to nor detracts from the effectiveness of an analogy. This effectiveness depends on the comparability of the relationships (Gentner & Gentner, 1983).

There are limitations to any analogy. Recognizing both the similarities and differences in an analogy can be quite useful in developing a clearer and more complete understanding of a concept. It is considered important that analogies be fully developed and expanded to include both the analogous elements as well as the limitations of the comparison (Bright, 1989; Galloway, 1990; Galloway & Bright, 1990; McGrath, 1990).

Methods

The research reported here examined the effects of varied exposure to analogies on subjects' conceptual understanding of computing, their ability to develop an analogy of some aspects of computing, and the degree to which they spontaneously generated and relied on analogies in explaining computing. It was anticipated that proper exposure to the instructional use of analogies would produce greater improvement in these areas.

Thirty-nine preservice teachers, beginners in computing, enrolled in a Spring 1990 required undergraduate computer literacy course (one semester hands-on with applications software and some programming), were divided into three groups (A-14, B-11, and C-14). Although random assignment was not feasible and participation was necessarily voluntary, there was no reason to assume that subjects enrolled in the three sections were not similar.

Data collection included both pre- and post-tests taken by all subjects and pre- and post personal interviews of four volunteers from each group. The written test consisted of part one (reliability: pre- .92, post- .76), which contained 55 questions that examined students' conceptual understanding of computing and addressed their understanding of fundamental computing concepts including command, data, file, language, program, variable, and computers in general. The test was expanded to include 8 questions (part two) involving short answer questions which asked the students to briefly describe an analogous comparison, outlining both similarities and differences. One analogy from the essay question coincidentally occurred in open class and was therefore dropped from the analysis. Essay questions were blind scored in random order with identification numbers and group designations hidden.

The pre- and post interviews involved open-ended questions and students were encouraged to discuss ideas and expand answers. The combination of open-ended interviews with written tests has been shown to be quite useful, effective, and even necessary in examining students' understanding of computing and conceptual changes in general (Finley, 1986; Galloway, 1990; Hobbs & Perkins, 1985; Posner & Gertzog, 1982).

The treatment of the three groups varied in the use and application of analogies in the classroom. Group A experienced a detailed analogy including a complete description of both similarities and differences. The students participated in expanding and developing each analogy and in identifying and discussing likes and limitations in comparison with the target concept. Group B also experienced an analogy presentation but it was simply mentioned succinctly without further discussion. For group C no analogy was presented—an inert computing fact was presented instead and all analogies were voided during the course. The groups were not specifically taught the content of the data collection instruments. The instruments contained material other than that used in the treatments.

Results

Pre/post "difference" improvement scores were used in the analysis because the subjects could not be randomly assigned. In spite of the fact that the small sample sizes per group proved too small to yield significant statistical data, interesting differences were found in both written and interview data.

Written Test

Results from the written test, parts one and two (55 multiple choice questions and 7 essay questions), indicate an overall improvement for all three groups on the post test. Table 1 shows the raw and mean difference scores for each of the three groups. Group A showed almost twice as much improvement on the overall test as either group B or C. There was almost no difference between B and C. On the essay questions groups B and C were, again, more comparable while group A scored higher than either.

Table 1

Written Test "Difference" Mean scores by Group

	Multiple Choice (55)		Essay (7)	
Groups	Raw	Percent	Raw	Percent
A (Full Analogies)	9.2	17%	2.93	42%
B (Simple Analogies)	4.0	7%	2.18	31%
C (No Analogies)	4.6	8%	2.36	34%

There was an interesting difference between groups' increase on the post test scores on only essay questions attempted. Students were instructed to respond only to those questions in which they had reasonable confidence. Group A showed a much greater increase over groups B and C. Of those questions attempted, scores for group A increased 70% compared with only 4% for group C. Group B's scores actually decreased 4% on essay questions attempted.

Interviews

In the first interview there was no significant difference between the groups. Table 2 shows the occurrence and the increase of spontaneous analogies between pre- and post-interviews by group. In the second interview there was a greater reliance in groups B and C on limited technical definitions. All subjects frequently used hypothetical examples to describe specific computing procedures, although group A expanded to conceptual descriptions more readily than groups B or C. In the second interview group A exhibited a much greater increase in the reliance on and spontaneous use of analogies.

Table 2

Spontaneous analogies between pre- and post-interviews by group

Number of Analogies Group	Pre-	Post-	Increase
A (Full Analogies)	10	50	+ 40
B (Simple Analogies)	4	6	+ 2
C (No Analogies)	6	11	+ 5

Group A's explanations were generally more involved, detailed, and conceptually based than the procedural examples or technical descriptions relied on in groups B and C. Comparatively, group A, more than groups B and C,used analogies of many things (roladex and index card files, address booklets, envelopes, fireplace wood, television, kitchen food processors, and more) as well as anthropomorphic references (memory and forgetting, conversation, the brain, thoughts and ideas, etc.).

Discussion

The greater increases for group A over groups B and C were quite interesting. The impact of these results are obviously diminished by the small sample size, the lack of statistical significance, and the fact that each interview subject's group was known to the interviewer. However, audio tapes and written notes of the interviews were scrupulously reviewed and the blind scoring of the essay questions promoted reliability in the data. Difference scores provide a comparison between groups which reflect their respective improvements without regard to any coincidental inconsistencies between groups.

Subjects in group A, who were exposed to fully developed analogies, showed the greater increase in reliance on and use of analogies in their ability to explain computing conceptually. Group A also showed greater improvements on the written test and a considerable increase on subscores for only questions attempted. Subjects' conceptual understanding of computing, their ability to discuss and explain computing conceptually, and the degree to which they spontaneously generated and relied on analogies in explaining computing seem to be positively affected by the proper use of analogies. This generative process of thinking critically with analogies helps students achieve a conceptual understanding and improved comprehension (Osborne & Wittrock, 1983; Wittrock & Alesandrini, 1990).

The ability to explain clearly and completely can be extremely important in teaching effectively and these results appear to indicate a value in the use of analogies. Also, the greater improvement on the overall test by group A seems to indicate that exposure to analogies can probably help to improve the conceptual development of beginning computing students. It is important for analogies to be fully developed with as much student participation as possible, outlining both similarities and limitations if benefits are to be realized.

Further research is needed on the uses and effectiveness of analogies with a variety of instructional goals and student populations. Research on other strategies and instructional tools could yield useful results.

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A Conceptual Approach Versus a Procedural Approach for Teacher Training in Technology

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Issues in Computer Literacy

A recent survey (Stieglitz & Costa, 1988) shows a growing amount of hardware in schools, but a trivial utilization of technology in the classroom and low teacher participation in training programs. We continue to read futuristic scenarios of computer use in the schools (Hoko, 1989) predicting that computers will be used extensively, both as stand alone machines and as part of complex communication systems, and that teachers will be more autonomous decision makers. However, there are few guidelines in the literature for getting to this point.

Transfer of learning is often mentioned in regard to students (Martin & Hearne, 1990), but this concept does not appear in the literature concerning teacher training in technology. Should teachers be expected to perform lower than students? The only cognitive task related to technology mentioned in the research is learning to program a computer using a programming language, e.g. BASIC (Dyck & Mayer, 1989). Programming skills might be important for certain curricula, but are not the commonly needed skills for present or future use of technology (Hoko, 1989; Van Merrienboer, 1990).

Computer literacy as a topic in the literature appears more from a curricular standpoint and not at all from the teaching strategy angle. The bigger part of the literature addresses computer literacy as a goal for school districts regarding their students, not their *teachers*. Teacher training is mentioned as a logistic problem (time for training, cost, who will train etc.) and not at all as a pedagogical issue.

Computer literacy as defined by Leuhrman (Leuhrman & Spain, 1984) is a derivative from the computer science field: one ought to know computer languages and different programming sequences. Leuhrman assumes that all teachers are not going to become computer literate and therefore recommends educating computer teachers, each of whom "must be a subject-matter specialist, not a grade-level teacher" (Leuhrman & Spain, 1984, p. 39). However, out of six experts interviewed, only Luehrman put programming as the central skill, while the rest recommended a curriculum which would provide students with "the ability to manipulate computer technology" (Leuhrman & Spain, 1984, p. 42).

At the same time that the discussion about priorities in a computer literacy curriculum continues, curriculum guides dealing with various age levels of computer literacy are being published. Most guides specify objectives and activities in two areas: computer awareness and programming (Bitter, 1982; Texas Education Agency, 1984). From the material published it does not seem that school officials understand what it means to "throw into the water" novices (in the computer field) and then expect them to function successfully in the classroom. In the Texas Education Agency document a five day sequence is suggested for teacher training—taking a university course is offered just as an option!

One more "bead on the chain" are demonstration sites, or "lighthouse schools" (Sense, 1984, p. 14). These schools are successfully utilizing technology in a variety of topics: from improving math and reading skills to more effective management of student records. We do not know, however, how these schools trained their teachers, which is obviously an important component for success.

Another View of Teacher Training

Technology Curriculum

What do teachers need to learn in an introductory course in order to be competent in today's technology? Looking at a widely used textbook (Bullough & Beatty, 1991), one finds some hardware concepts, like modems and alternative input devices, but mostly software concepts, like spreadsheets, data bases and instructional programs. This particular textbook groups different computer uses in three categories: using the computer as a tool, as a tutor, or as a tutee. Tool applications are general purpose like a word processor, tutor mode is for computer-assisted instruction, and tutee mode is when a user is programming. Even a superficial look at society at large reveals that the first two applications are far more used and more needed than the last one.

In this view programming is not eliminated from the curriculum, but it shares a smaller proportion. Its function within the proposed curriculum is more to increase comprehension of computer phenomena than aiming to master programming.

Instructional Approaches

The Procedural Approach. Many literacy courses use a *procedural* approach, i.e. have the learner repeat a long string of steps in order to succeed in a computing task. For example, a list of key strokes is presented to the learner and he/she is supposed to repeat the key strokes in order to open a word processing file and type in some information. The term procedural was used by Reigeluth (1983), who identified four major types of instructional structures: conceptual, procedural, theoretical and learning-prerequisite.

If a procedural teaching method is the major one used in entry level computer courses, it most likely encourages "list learning" strategy (Mayer & Cook, 1984) to be employed by the learner. In this strategy the learner tries to remember verbatim as many pieces of information as possible. Finally, the information provided by the trainer and the strategy employed by the learner, both produce a repetition of the modeled performance, but not any transfer to new situations.

The Conceptual Approach. In this approach to instruction a trainer would use conceptual structures as a major teaching method to novice learners. Main lesson components are *concepts* (groups of things) and not fragmented details, like key strokes or particular programs. Concepts are put in a *conceptual structure*, where interrelationships among concepts are stressed. Appropriate concepts might group programs by program type, like *data bases*, by program operation, like *menu-driven programs*, by program features, like *programs with a configuration menu*, by instructional qualities of programs, like *programs providing guidance to the learner*. Criteria for grouping programs would vary with course objectives. In the course described below all the above groupings were used in order to prepare a computer-naive teacher to identify known features when encountering a new program - both operational features and instructional features. The actual sequencing of instruction was done as an "elaborative sequence" (Reigeluth, 1983, p. 343), where the trainer always started with a small number of ideas that were to be taught in the course, presenting them in a concrete and meaningful way.

This conceptual approach to instruction has assimilated two main influences: the elaboration theory of instruction (Reigeluth, 1983), and the use of conceptual models to enable transfer (Mayer, 1989). Mayer (1989) reviewed the literature on presenting conceptual models prior to a lesson, and on presenting models within a lesson. These models described technical systems (e.g. radar, brakes in a car, and even human information processing) in a pictorial representation. This representation highlights key concepts from the to-be-learned material, and suggests relationships among them. Using models improved conceptual retention, reduced verbatim retention and improved problem solving transfer in comparison to control groups (Mayer, 1989). Therefore the use of concrete/pictorial models has been incorporated into the conceptual approach.

Project Description

The conceptual approach has materialized into a graduate course for computer-naive teachers. The teachers typically take the course as part of an 18-hour sequence for renewal of certification. Few of the students prior to the course or during the course declare educational technology as an emphasis area in a masters program. The following are the main components of this course.

Actual Curriculum

The course includes fourteen topics as an overview of computer applications in education. These fourteen topics are taught in reference to the classification system by Taylor (Bullough & Beatty, 1991): computer as a tutor, as a tool, and as a tutee. Specifically the most important course objectives are for students to identify, at the end of the course, program type/genre (which programs fit which genre, how to use them and for what purposes) and to be familiar with computer literacy concepts by showing comprehension in a nonverbatim test.

In order to obtain these objectives, a textbook was chosen and additional content was added. The entire content of the course is organized by concepts, but these have been integrated into the course from different sources, and may be classified as following: A. Concepts mentioned in educational technology textbooks where concept name and definition are typically provided, e.g. "Tutorials", "simulations", "integrated programs" and more; B. Concepts from the field of computer science that are just mentioned by name and not defined by the above mentioned textbooks, e.g. "default", "variable", "string", "screen dump" vs. "print file"; C. Invented concepts to include concept name and definition, e.g. "configuration menu", "program structure" and more.

All concepts were included to promote a *holistic view* of each program, or group of programs, and to outline *common features* and *principles of operations*, like: "you start by looking for a configuration menu, making necessary adjustments, and return to main menu; if you worked with this setting before do not 'touch' the configuration menu". This reflects the view of what constitutes computer literacy - concepts and principles.

Instruction

Each class session is composed of two parts: first, lecture/discussion and second, computer laboratory experience. Pure lecture is very short and the class quickly moves to a discussion mode. New concepts are presented using paper models, metaphors, diagrams projected from transparencies, and colored illustrations on the white board. New concepts are related to old concepts by way of similarity or difference ("a file of a spreadsheet is not like a file of a word processor"). Programs introduced as examples to the lesson's topic are projected on a large screen (via LCD plate or SONY 3 gun projector). While the program is being projected and manipulated by a graduate assistant, concepts are being applied and then recommended procedures are modeled. For example: "COLOR ME has a hidden configuration menu; just by following the instructions on the screen a child is not going to find it; let's follow what the manual says and adjust the program to our needs..."

The teachers taking the course are not being dealt with as learners of computer topics only, but also are being prepared to act as teachers to teach computer literacy to their students using a conceptual approach. For example, one of the assignments is to prepare the first lesson plan in the sequence of teaching a word processing program to their students. The teachers choose a program of their liking which seems to match their clientele (early elementary, mid-elementary, secondary, LD students etc.); they prepare visual aids to represent metaphorically program structure; and finally a typed lesson plan is prepared which outlines a sequence that starts from the analogy (metaphor, story) and slowly proceeds to an introduction of a guided task and later an independent task in using the word processor.

Data Collection and Results

The computer literacy course is in its fourth semester. Data from the first three semesters of pretest and posttest performance was analyzed. The sample included 53 teachers, 13 males and 40 females. They were tested before and after the course by the same 11 item multiple choice test. Another way of looking at the sample is by entry level. Dividing the 12 possible scores (0 - 11) into three subgroups, High, Medium and Low, there were 9, 39 and 5 teachers respectively.

The sample of 53 teachers represented more than one population: Male teachers initial performance (M=6.69) was significantly higher than Female teachers initial performance (M=5.93, t=1.30, $p<.10$). As far as different levels in the course, they were also significantly apart (M/Low=2.20, M/Medium=6.03, M/High=8.67, F=74.03, $p<.01$).

The following tables present achievement of the total sample and achievement by group. Control groups were not set up, so data regarding the 53 teachers is the only data available in this set.

Table 1
Measures of Students by Gender, Entering and Completing the Computer Literacy Course

Group	Pretest	Posttest	% of Increment
Male			
n	13	13	
M	6.69	10.00	49.48%
S.D.	1.49	1.00	
Female			
n	40	40	
M	5.93	10.13	70.83%
S.D.	1.95	0.91	
Total Sample			
n	53	53	
M	6.11	10.09	65.14%
S.D.	1.87	0.93	

All teachers showed a substantial percent of increment of their computer literacy knowledge after the course (see Table 1 and Table 2). Standard deviations tended to decrease in posttest scores in comparison to pretest scores; the only exception is the Medium group where standard deviation increased slightly. As a general rule the groups which started the course the lowest increased the most, while those who started highest increased the least.

Table 2
Measures of Students, by Achievement Level, Entering and Completing the Computer Literacy Course

Group	Pretest	Posttest	% of Increment
High[a]			
n	9	9	
M	8.67	10.33	19.15%
SD.	1.00	0.87	
Medium[b]			
n	39	39	
M	6.03	10.03	66.33%
SD.	0.90	0.93	
Low[c]			
n	5	5	
M	2.20	10.20	363.64%
SD.	1.30	1.10	
Total Sample			
n	53	53	
M	6.11	10.09	65.14%
SD.	1.87	0.93	

Note. Group divisions are based on student scores when entering the course. [a]High = students entering with a score of 8 or above; [b]Medium = students entering with scores of 4-7; [c]Low = students entering with scores of 0-3.

In a t-test of nonindependent samples, each group's pretest and posttest was compared (see Table 3). The total sample posttest as well as each group posttest was significantly higher than the relevant pretest. When comparing posttests between groups, no significant difference was found: Male vs. Female, t=-.42, df=51; High vs. Medium vs. Low, F=0.43, df=2/52.

Discussion

The data presented should be considered a pilot effort. To claim causality, some sort of design including control groups should be established sometime in the future, comparing *different* teaching methods of computer literacy.

The numerical results reflect the goals of the course, and its test design. The course was designed for teachers without formal prerequisites in computer literacy, so high variability among enrolling teachers was expected. The test itself has only 11 items and could not show much of an increment in the High group. The decrease in standard deviation was another goal - to create a more homogeneous population of teachers, when they go out to apply what they have learned in their classrooms; or if they choose to go on to the next course in the sequence of education technology.

The 11 item test asked for nonverbatim definitions of computer literacy concepts (e.g. "default", "immediate mode", branching") and did not refer to the method of instruction - the conceptual approach. Even without a control group, one can see that using the conceptual approach as a teaching method, and asking teachers to incorporate it in their own teaching, did not prevent

Table 3
t-Test for Nonindependent Samples, Comparing Pretest and Posttest of Each Groups Means

Group	*n*	Pretest *M*	Posttest *M*	*df*	*t*-Value
			Achievement by Gender		
Male	13	6.69	10.00	12	7.04*
Female	40	5.93	10.13	39	13.13*
Total Sample	53	6.11	10.09	52	14.74*
			Achievement by Level		
High	9	8.67	10.33	8	4.51**
Medium	39	6.03	10.03	38	21.05*
Low	5	2.20	10.20	4	9.52*
Total Sample	53	6.11	10.09	52	14.74*

*p<.0005. **p<.005.

teachers from success in a computer literacy measure. The groups who came into the course so different (Male vs. Female and Low vs. Medium vs. High), finished the course as one population without significant differences among them. The course seems to be effective for every group regardless of initial starting point.

Future investigations into the conceptual approach of teacher training in technology should go beyond the course framework and into the classrooms, where teachers work in applying technology into their own situations. Different applications could be compared and analyzed vis-a-vis teacher preparation programs.

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The Case-Study Method and Computer Assisted Instruction in Teacher Education

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The Case-Study Method

Case studies provide problem solving experiences for students. As a teaching device, the method has become very popular in many fields—most notably in medicine, business, and law. Christopher Langdell, a professor of law at Harvard University in the late nineteenth century, is credited with introducing the case-method of instruction to American higher education (Vagts, 1977). Although business and law have perfected the case-study method, variations of the basic features of the case-study approach can be found in most fields of study.

The Case-Study and Computer Assisted Instruction

A search of the literature regarding the use of the case-study method combined with some form of computer assisted instruction yielded few entries. One example of an interesting interactive case technique using computers was described by Newell Chiesel (1979) from Western Illinois University. The format used was a simulation of a hypothetical business, with multiple problems, existing in a changing environment. Because of the interactive capabilities and the immediate feedback available to the students, the computer adds to the basic case-study approach.

A second example of the case-study method combined with some form of computer assisted instruction is the computer-aided legal instruction introduced into the Harvard Law School by Professor Robert Keeton. Professor Keeton (1976) developed computer-aided exercises in Insurance Law, Tort Law, and Trial Advocacy in the early 1970's. A bank of computer-aided legal materials has been developed at Harvard in response to a growing demand for high-quality computer based lessons.

The third example of the integration of the case-study method with computer assisted instruction comes from James Lengel who developed seven interactive computer programs to help with the study of American History (Budin, Kendall, and Lengel, 1986). The two programs, using the case-study method, look at the *Brown v. Board of Education* desegregation decision and the *Tinker v. Des Moines* Supreme Court case involving students' rights. Students are presented with the facts of the landmark cases and led through the legal issues involved. They study the relevant Constitutional provisions from a database of Constitutional citations and finally render an opinion. The database provides the main tool available for research by the students.

The Case-Study and the School Law Database in Teacher Education

The School Law Database project, now in its third year at the University of Michigan-Flint, illustrates another way the case study method can be successfully used with computer assisted instruction. Students in the Social Foundations of Education course use written guides and a database of prominent court cases to examine case studies on topics ranging from censorship to religion and education. Several reasons prompted the development of the School Law Database project.

1. It provides a single source of significant court cases related to education.
2. It supplements class lectures and discussions.
3. It is flexible and can easily be updated.
4. It can be used in a variety of courses.
5. Students gain experience with CAI.

The pilot program involved entering data from over seventy-five court cases organized in fifteen fields. Once the information on the court cases had been entered in the database, six case studies were developed and designed to supplement class lectures and discussions . The topics included: (a) Teachers' Academic Freedom; (b) Students' Rights; (c) Religion and Education; (d)Segregation and Education; (e) Financing Public Education; and (f) Special Education. The computer allowed easy access to the information on court cases that was necessary for students to work through the assigned case studies.

Student Evaluation of the Project

Students were asked to evaluate six elements of the computer assisted instruction segment of the course. A summary of student' responses indicated that 82.7% gave the segment the highest rating and 13% the next highest of five ratings. Students found working with the case-study method combined with computer assisted instruction to be enjoyable, challenging, and helpful in their understanding of the class material.

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Using Technology in Teacher Education: Facilitating Development or Maintaining the Status Quo?

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Education has been inundated by demands for reform: reform in how students in the public schools are educated, reform of educational programs for undergraduates, and the reform of educational programs for prospective teachers. Various factors contribute to the demands for the reform of teacher education including an expanding knowledge base; the failure of the schools to effectively educate a significant proportion of students, many of whom are minority students; and attempts to professionalize teaching. Implicit in most of the reform recommendations is a focus on educating students to become critical thinkers who will be prepared to be life-long learners; learners who can become active, contributing members of an increasingly technologically oriented society; and as professionals, individuals who will critically inquire into their own practice.

In this paper, theories of adult development provide the conceptual framework for a discussion of how technology can be used to facilitate the conceptual, epistemological, and professional development of prospective teachers. If teacher educators hope to prepare teachers who will be critical inquirers into their own practice, development must be a consideration, for critical inquiry and development are related in significant ways (Kitchner and Kind, 1990; Oja and Smulyan, 1989). Three computer assisted activities — Learning Tool ™, the Diverse Perspective Exercise (DPE), and CONFER II™, — used in teacher education programs at The University of Michigan will provide the specific focus for a discussion of how technology can be incorporated into teacher education programs to facilitate the development of prospective teachers.

Learning Tool includes concept mapping and may be used to facilitate students' conceptual development (Hunt, 1975; Deshler, 1990). The Diverse Perspectives Exercise uses role playing to give students an understanding of multiple perspectives. The ability to take more than one viewpoint into account when making decisions may be related to conceptual and epistemological development (Hunt, 1975; Kitchner and King, 1990; Selman, 1980). CONFER II provides a structure for enriching prospective teachers' practical arguments and thereby their professional development (Fenstermacher, 1987). These activities reflect an underlying assumption that learning to teach is a complex cognitive process. It is as essential for prospective teachers to see themselves as learners (and for us to see them as such) as it is for them to see their students as learners. Learning Tool, DPE, and CONFER II may all be used to help students reflect on their own learning and expand their ways of knowing. This will occur most effectively if learning technology is implemented with that goal in mind. Without a clear conception of the objectives supporting its use, the incorporation of technology may, in fact, lead to a negative outcome by inhibiting development and reifying existing misconceptions.

Developmental Perspectives

Models of adult development can inform teacher educators as they attempt to strengthen educational programs for prospective teachers. This is particularly true if the facilitation of prospective teachers' conceptual development (what they know), epistemological development (how they know), and professional development (how that informs their work) is one of teacher educators' goals. Given the forecasted changes in the public schools (Hodgkinson, 1985) this may, indeed, be a necessary goal for all teacher education programs. As we become increasingly aware of teaching's ill-structuredness, enabling new teachers to deal with this complexity becomes an ever increasing priority. Models of adult development provide insight into the skills and dispositions that are necessary if teachers are to be able to deal with teaching's complexity in effective ways. It is at the most sophisticated levels of development that individuals accept the tentativeness of knowledge; and, accepting the tentativeness of knowledge, are able to make decisions using best evidence criteria with evidence being broadly defined (Hunt, 1975; Perry, 1970; Kitchner and King, 1990). At mature levels of development individuals are able to appreciate diverse perspectives and acknowledge and accept the interdependence of systems (Selman, 1980). Individuals functioning at high levels of development are able to operate autonomously and frame their actions in an ethic of care (Loevinger, 1976; Noddings, 1984).

If those are our goals for the education of prospective teachers, how can we achieve them? How can we build programs for prospective teachers that foster critical reflection and nurture transformative learning? Each of the technologically based experiences to be discussed below have that potential. They can support teacher education programs that are more cognitive, more learner centered, and more critically reflective than programs have been in the past. Each experience may facilitate development and in doing so provide prospective teachers with the skills and dispositions they can carry into their professional lives, skills and dispositions that will benefit the learners in their care. Each offers a way to facilitate the practical arguments of teachers. And practical arguments offer a way to connect the heart and soul of teaching with the science of teaching.

Few of us are satisfied with conceptions of teaching that rest on the metaphor of the teacher as a kind of vehicle, transporting knowledge and understanding from text, film, museum, or workbook into the mind of the learner. Nor does the teacher as producer of learning gains on standardized tests of achievement hold appeal for many [teacher educators]. Though unhappy with simple-minded views of teaching, we have not made much progress in finding alternatives that are both grounded in defensible normative theories of education and efficacious in the setting of modern school classrooms. Practical arguments offer a way to join normative theory of education with empirical descriptions of effective teaching (Fenstermacher, 1987, p.415).

Using Technology to Facilitate Teacher Development

Prospective teachers need to be prepared to function as professionals in an increasingly technologically oriented world. They also need to prepare their students to do the same. But as we redesign programs to accomplish the aim of preparing teachers to use technology, we should, in turn, use technology to strengthen our teacher preparation programs. In doing so, we model what we want our students to learn. We demonstrate to students that the thoughtful incorporation of technology can facilitate and enhance the learning of all students. Each of the technologically-based activities that will now be discussed has that potential.

Learning Tool: Facilitating Conceptual Development?

Learning Tool was designed by faculty at The University of Michigan and may be used at various points in the curriculum. It is a software program designed to help students learn how to learn. Incorporating principles of cognitive psychology, Learning Tool provides students with a model of how they learn as well as how to learn more effectively. An essential aspect of this software program is concept mapping. Although all learning results in conceptual change, concept mapping is a technique that can be used to help students gain insight into their understanding of specific concepts — how they are organized and related (Deshler, 1990; Novak and Gowin, 1984). Concept maps are graphic representations of what students know at a particular point in time and reflect the relationship between thoughts,beliefs, values, and feelings. Concept mapping can be used to provide students with opportunities to reflect on how they have constructed what they know as well as how that construction may facilitate or confound future learning.

Conceptual awareness and conceptual development are particularly relevant to the education of prospective teachers. Lessons which are conceptually sound are more flexible and responsive to the needs of individual students. When prospective teachers are aware of their own conceptual understandings they may be better able to provide the multiple representations of concepts their students need (Wilson, Shulman, and Richert, 1987). But researchers are finding that teachers frequently have misconceptions which they convey to their students. It is therefore essential that concept mapping be incorporated in a way that it strengthens prospective teachers' understandings rather than reifying existing misunderstandings. Dialogue may be a necessary addition to concept mapping. When dialogue is included with concept mapping, students' graphic representation of concepts help them begin to identify limitations and misconceptions in their thinking.

We need to test the validity of our concept maps through dialogue and through comparisons with the thinking and concept maps of others. Dialogue forces us to make explicit to others what seems clear to us but may, at the same time, be flawed. It is the process by which we can validate our thinking through comparisons with what others think. Challenges to our misconceptions are more likely to occur in dialogue than when we are by ourselves (Deshler, 1990, p.346).

Much of the effectiveness of concept mapping as a way to facilitate development may lie in its potential to refine individuals' construction of knowledge through dialogue. But it may be limiting for the teacher to be the only one providing feedback on an individual's map—that might lead to a "right" conception and inhibit a student's reconstruction. With the support of peers and instructor, students will work toward better conceptions while developing skills in reflection. Concept mapping, with the inclusion of dialogue, can "provide a basis for negotiating shared meaning and social communicative validation" (Deshler, 1990, p.336). Learning Tool includes this possibility.

But a willingness to step outside the bounds of "authority" is developmental. Therefore, students' conceptual development may be limited by their epistemological development. In order to maximize the potential of our programs to facilitate student development, we must do a better job of integrating our programs. As we attempt to facilitate student's conceptual development, we may need to acknowledge and facilitate their epistemological development as well. The Diverse Perspectives Exercise offers a way to become aware of how students know. It may also provide opportunities for enhancing students' ways of knowing. Incorporating and integrating activities such as concept mapping via Learning Tool and the DPE may allow us to begin to maximize student development.

Diverse Perspective Exercise: Facilitating Epistemological Development?

Prospective teachers need to know in a variety of ways. They need to understand schools and the teaching and the learning process from several perspectives including sociological, psychological, and cultural perspectives. Perhaps most importantly, they need to know from a pedagogical perspective. And as Shulman (1989) indicates,

"...if what we mean by a pedagogical way of knowing includes being able to know, not only from your own perspective but from the perspective of the other, then one of the ways in which we ought to organize the . . . education of future teachers ought to be around the kinds of educational experiences that give them opportunities to learn to take the role of another in history, literature, or science and to learn to think in those terms—highly contextualized, highly case specific, quite historical, biographical, and cognitive. And in doing so, you're not only learning science, literature, or history; you're learning to think in a discipline, you're thinking pedagogically (Shulman, 1989, p.22)."

The Diverse Perspectives Exercise is designed to provide these kinds of opportunities for prospective teachers. It is included in an educational foundations course but could just as well be included in other teacher education courses. The exercise is a combination of role playing, case methods, and communication (see the papers by Bair and Anderson in this volume) and is intended to give students practice at problem identification and problem solving (Arlin, 1989; Sternberg, 1984). Another goal of the exercise is to make students aware of how educational problems are viewed from a variety of perspectives and to give them a sense and appreciation of the validity of these diverse perspectives.

The problems that the students work with in the course of the exercise are ill-structured problems and, therefore, not easily resolved. They are typical of most problems in education in that there is often 'conflicting or incomplete information,' [they] have unknown, unspecifiable, or even conflicting problem characteristics and lead to more than one of a number of solutions that are neither certain nor verifiable (Brabeck and Wood, 1990, 133).

Strengthening students' ability to deal with these aspects of problem identification and problem solving (multiple perspectives and ill-structured problems) may facilitate their epistemological development as well as giving them a greater understanding of the context complexity of the teaching and learning process. But in order to accomplish these goals, students' various levels of epistemological development must be considered and attempts made to build on this diversity in the course of the exercise. The "problem of the match" (Hunt, D., 1975; Hunt, J. McV., 1961; Vygotsky, L. 1978) is as relevant in the facilitation of adult cognitive development as it is with children. This makes the incorporation of an exercise as complex as the DPE extremely problematic.

During the DPE students receive feedback from their peers, all of whom are taking a variety of roles. In addition, the students' problem identification and solution are guided by the content in the course, the instructors presentation of that content, and the graduate assistants working with them. The interactions that occur may either facilitate or inhibit student development. Those functioning at less mature levels of epistemological development may not be able to deal with the ambiguity of the problems without a great deal of support. Non-supportive feedback may cause them to disengage or to look to authority for "the" answer. Those functioning at more mature levels of development may be able to reflect on action and open their beliefs to change, based on rigorous evaluation of the evidence provided through feedback. We need to know our students as learners. We need to understand how they have constructed their knowledge and how they know, if we hope to facilitate their learning. We expect this of them when they become teachers. Can we expect any less of ourselves? This is difficult and time consuming and might not be possible without the computer component of the exercise. We have a permanent record of our students' interactions and can assess the transcripts in light of what we know about development. Technology allows us to maximize the potential of the activity to facilitate student development, in this instance, the students' epistemological development.

Exercises like the DPE coupled with activities like concept mapping allow us to focus on developmental characteristics of prospective teachers, but more importantly, they provide the information necessary for the facilitation of that development. By building on the capacity of computer technology to manage extremely complex exchanges of information, these kinds of activities, if used thoughtfully, may allow us to maximize student development. Concept mapping can show us and our students how what they know is structured. The DPE can show us and our students how they know. Together they provide teacher educators with opportunities to enrich student learning in multiple ways.

> Ideas that are novel, powerful, and profound are very difficult for us to think about; we need time and some mediating activity to help us. Reflective thinking is controlled doing, involving a pushing and pulling of concepts, putting them together and separating them again. Students need practice in reflective thinking [and]...the computer programs we are now developing may facilitate such practice in thinking (Novak and Gowin, 1984, p.19).

CONFER II: Facilitating Teachers' Practical Arguments?

Ultimately we want to prepare teachers as critical inquirers into their own practice. As the schools and the nature of their students change, teachers must question if what they are doing is the best way to facilitate the learning of their students and, if so, with what consequences. Teachers must be prepared to deal with the dilemmas they will be faced with throughout their professional lives. Using concept mapping in methods courses helps to assure that teacher education programs help students develop the conceptual knowledge needed to teach their content effectively. The DPE used in foundations courses helps students begin to develop an awareness and appreciation for diverse perspectives and in doing so may expand their ways of knowing. Using both in programs for preservice teachers allows us to know them more completely as learners and "match" the program to their needs so that we facilitate development.

But prospective teachers also need time to reflect on the real world practice. If we hope to prepare them as critical inquirers, programs also need to be structured to provide guided feedback on that reflection as well as guided integration of all of the components of their programs (Sprinthall and Theis-Sprinthall, 1983). Computer conferencing (CONFER II) used in the field component of programs could provide students with the opportunity to draw connections among the disparate elements of their programs and to make connections between what they have learned and what they see in the field. It may also be a way to provide students with guided feedback on the decisions they make.

The feedback provided, via computer conferencing, by peers and faculty on the decisions made and concerns raised by prospective teachers while in the field has the potential to facilitate their practical arguments. Practical argument allows prospective teachers to see how research connects to practice. Building opportunities for prospective teachers to engage in practical argument in teacher education programs may help overcome the "feed-forward" problem — getting information before they have experience to connect it to — that is a common complaint of new teachers.

> Research connects to practice when research is used to alter the truth value of existing premises, when it is used to complete or modify empirical premises, or when it serves to introduce new empirical premises in the practical arguments in the minds of teachers (Fenstermacher, 1987, p.413).

When practical argument is used in this way it generates critical inquiry. The intent of the use of computer conferencing should be to help prospective teachers examine the way they frame problems and to "become aware of tacit frames; the description of images, category schemes, cases, precedents, and exemplars which help [them] build repertoires" (Confrey, 1987, p. 387). But this requires active, intensive monitoring of the conferences and ongoing guided feedback, reflection, and integration. In this way prospective teachers become aware of the completeness of [their practical] argument, about its overarching moral goals, about the accuracy and soundness of its empirical claims, or about the [prospective] teacher's description of the present situation. Such questions are intended to alert the teacher to possible reinterpretations, to different ways of perceiving the situation, to new evidence that might bear on the goals, or to value conflicts in the aspirations the teacher has for students (Fenstermacher, 1987, p. 416).

Without this feedback, computer conferencing may simply validate teaching's "folk wisdom" rather than enriching potential teachers' understanding of the teaching and learning process.

Conclusions

The computer assisted activities discussed in this paper have the potential to help teacher educators prepare prospective teachers as effective learners who function with a high degree of professionalism and are committed to providing an equitable and quality education for all students. They have the potential to facilitate our students' development in a variety of ways. Too often new innovations have been incorporated with no clear conception of what educators hope to achieve and, therefore, fail to strengthen the education of students (Popkewitz, Tabachnick, and Wehlage, 1982). As this paper implies, the student as learner must always be our primary focus. The method should always be secondary. Choices among methods must be made on the basis of how effectively they help us facilitate the learning of our students. Models of adult development inform that choice. The inclusion of learning technology in educational programs may facilitate student development or help to encourage the status quo. The outcome is, in large measure, determined by the manner in which technology is incorporated.

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Diverse Perspectives On Education: Connecting Theory and Practice in Teacher Education

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Introduction

The Diverse Perspectives on Education exercise is a computer-assisted role playing activity designed for undergraduate teacher education students in their social foundations course. For many students, this is the only education course they receive which addresses educational philosophy and history, and the theoretical implications of these fields. It is often unclear to many students, who more often are seeking practical methods and information which can be readily used in the classroom, how such a course is useful. Our goal in developing a simulation exercise was to bridge this gap between scholarly expectations and students' desires, a problem typically expressed in terms of a gap between "theory and practice." The Diverse Perspectives on Education exercise is designed to provide students with an opportunity both to apply information that they have learned in their teacher education program to situations that they might face in actual schools and to gain insight into how their decisions might be viewed from a wide variety of perspectives. Although designed by a group of faculty and graduate students at The University of Michigan [1] and intended for use in the course called *Education in a Multicultural Society*, the Diverse Perspectives exercise from the outset has involved students from other colleges and universities in order to bring a maximum range of diverse experience and training to bear on the problems presented. The multi-campus nature of the exercise is made possible by the use of the CONFER II (TM) computer conferencing system, which allows for the management of an extremely complex exchange of information among people at distant locations. This exercise grows out of eight years of experience with similar simulations developed and managed by the Interactive Communications and Simulations (ICS) program headquartered at The University of Michigan.[2]

The exercise, or "game" as it is commonly referred to, involves approximately 50 students, with multiple games being conducted simultaneously in larger courses. The students are engaged in two consecutive games, one during the first half of the course and one during the latter part. In each game half of the students are asked to participate as teachers early in their careers; in a sense, to "role-play" themselves in a few years. They are charged with the task of reacting to "cases" involving complex, multicultural phenomena in schools as they themselves would react. This reaction or course of action is typed as a public item in the computer conference.

The other half of the students play specific characters taken from an extremely diverse set of people, called "consultants," whose views on education are to be studied carefully and represented with as much vigor and accuracy as possible. The premise of this part of the exercise is that these actual people, both living and deceased, have been hired by the School of Education as consultants, to observe our recent teacher education graduates and make helpful suggestions and evaluations. Students, each playing one of these characters, write a role profile which they type in the conference, introducing themselves to other participants and presenting a summary of their beliefs which may be applicable to education. We do not limit the consultants to those who directly discuss educational issues; our consultants have included such diverse individuals as Cesar Chavez, Carol Gilligan, Eleanor Holmes Norton, Michel Foucault, and Margaret Sanger, as well as such prominent educationalists as Ron Edmonds, Maria Montessori, Jaime Escalante, Mary Hatwood Futrell, and Allan Bloom. Our goal is to include theorists, historians, social consultants and social activists.

Each game lasts about five to seven weeks with the two sets of students switching roles between games. The cases are changed for the second game and all of the "consultants" are different from those played during the first game. The game is supervised by one or two graduate students who also serve as discussion leaders for seminar sections of the course. Students are also assigned a specified group with whom they talk via the computer conference, which sets in motion continuous and complex dialogues, expanding with each student's interests, knowledge, and capacity.

This exercise, as well as the course in which it is used, has specific goals which underlie its development. As in most courses, there are specific content goals which include familiarity and understanding of important ideas, trends, and movements in education both current and historic. Such content goals are traditionally measured through evaluations of tests and written work, making it relatively easy to determine the students' level of competence. More elusive are process oriented goals, especially those which encourage the development of a student's capacity to analyze new situations. The development of the intellectual skills involved in such analyses is an equally important goal for students, particularly those who aspire to be teachers. It is difficult, though, to know if students have improved their capacity to solve problems. This exercise provides an opportunity to model, observe, and reinforce such processes in students, particularly through their responses made in the computer conference. The exercise encourages students to bring theoretical and scholarly knowledge to bear on the everyday practical world of teachers.

Content Goals

The Diverse Perspectives exercise supports the content goals of the course *Education in a Multicultural Society* in at least three ways: 1) exposure to current educational issues; 2) in-depth knowledge of one consultant; 3) secondary knowledge of other consultants with whom discussion takes place.

In preparing the written consultant role profiles, students are required to do basic research on their character. Of course this challenge is different for different roles. Some characters, such as John Dewey, have shelves and shelves of books in the library, let alone the commentaries and historical reviews of his work. The challenge for the student is to find the drop within the ocean — to choose what to read and what not to read carefully. On the other hand, finding any written information for some consultants is difficult. Several of our consultants are contemporary educators, practitioners, or politicians, such as Deborah Meier or Henry Cisneros. In these situations, the student is challenged to find any information at all, searching newpapers, government records, or even calling the person on the telephone for a short interview. Granted, these two examples do not represent necessarily equivalent exercises for the students, but each is a challenging activity in and of itself.

While students did submit their written work to the faculty for assessment, it should be noted that evaluation of writing style of responses in the computer conference is adamantly avoided. This is done for several reasons. The computer conference is a medium which functions somewhere between verbal and written expressions. We encourage students to write/type responses often, expressing ideas which need not be fully formed or perfectly articulated. This would be similar to how one might encourage participation in a seminar discussion. If students believed that every comment made on the public conference was going to be evaluated for style and content accuracy, some students would participate less, and most certainly be less spontaneous. It is precisely that spontaneity that produces some of the most exciting, and educational, discussions. At the same time, we encourage a high level of tolerance and patience among participants. When communicating via computer, one does not have the advantage of non-verbal communication or the opportunity to ask immediate clarifying questions. We encourage participants to assume the writer had the best intentions, and if a question arises, ask her/him to clarify. In most cases people were amazingly polite yet direct, asking for clarification whenever confused.

Process Goals

This analysis of the transcripts demonstrates how the Diverse Perspectives exercise enhances both personal and professional development of the students in five ways:

1. Development of a personal pedagogic creed.
2. Interaction with others though dialogue and discussion.

3. Development of an openness to diverse perspectives.
4. Consensus building.
5. Enhancement of field experiences.

These goals will be discussed individually, but their inter-relatedness will become apparent as the discussion proceeds.

1. Development of a personal pedagogic creed

All students are required to write a two page response to one of the cases as teachers, projecting themselves a year or two into the future. The cases, developed by graduate education students, present a problematic situation which requires the student's attention, including issues of curriculum development, student discipline, equity issues, language, and culture. By making a public response, students have to consider their own position and priorities, which serve as the impetus for the development of a personal pedagogic creed. In many responses, students clearly lay out their assumptions and values which undergird their position. One example will demonstrate this:[3]

"T 36: . . . Here are the things I believe (my values) that will determine what I will do in regard to this student. First, I don't easily accept that something is impossible. Secondly, I believe that children deserve opportunity that is commensurate with their desire and ability. Third, I believe that any effort to assist a child's growth and development at any point, even if it falls short of achieving the goal, is of value to that child. Forth I believe that few situations remain static. Therefore, what circumstances dictate can't be done today, may be possible tomorrow. It is important to act as if the goals are possible because that may turn out to be so. Fifth, while I don't believe that teachers can "save the world," I do believe that they must make their strongest effort for those children who cross the threshold of their classrooms.

Now, how do I translate these values into practical action?" (I 146)

Through writing responses to cases, students had to translate their personal values into practical action. More than just an abstract document, this personal response gives students a means of developing inroads to "best practice" and a basis from which to consider viable alternatives.

2. Interaction with others though dialogue and discussion

Discussion is what this exercise is all about. Students were constantly in dialogue with others. Clearly, some people brought their own personality into the play of their consultant, sometimes creating actual ideological conflict between members of the game. Was this personal or simply within the role playing exercise? There are examples of both. In one case, the character playing Michel Foucault pointedly challenged the forces of authority and power within the dialogue in Allan Bloom's role profile, and later actually sent a cryptic message reminiscent of a suicide note within the same dialogue (being the point in the game when the student changed roles from being a consultant to a teacher; in effect, Foucault did "cease to exist" within the context of the exercise). The discussion and eventual "Lamentation for Foucault" which this prompted was clearly both educative and fun for the participants.

In another example, the characters of Jerry Falwell and Henry Cisneros continually clashed over religious issues, from the historical accuracy of the Bible to specific metaphysical criticisms of the Gospel. Clearly, both participants believed deeply in what they were saying, demonstrated by comments in class and on the conference. Yet, as vociferous as the dialogue became at times, each conceded to the other that the positions were well considered and forcefully argued, giving each other and remaining participants much to think about regarding these important questions.

One might ask to what extent this discussion encourages reflective thought among the participants. In one sense it does structure their experience such that they are required through specific assignments to think about an issue, talk about it, and then rethink their position. This process did occur in numerous places, as shown through examples of their "talk" on the computer conference. In discussing oppression and its impact on the less powerful, the following exchange took place:

"A. S. Neill: I wonder sometimes at the extent of the hurt to the oppressor as well as the oppressed. In some aspect of ourselves we are all oppressed in this society. As a male I have much unasked-for power and at the same time many expectations as to the use of that power."

"T 8: . . . I was thinking about that today. As a white female I can relate with the statements brought up in class about not trusting men. Then today I thought to myself that with my feminist beliefs in place it is quite possible that I have in a way become "desensitized" to the white male perspective, but at the same time I wonder if that is possible." (I 3)

In response to Jane Roland Martin's role profile, which discussed the historical changes in how we view the education of women, a student addressed the conflict she recognized between her experiences and what she was reading:

"T 48: I don't understand: Are you advocating Plato's views? Can you explain those a little better to a non-philosophy major? Personally, reading all of the role profiles from feminists and the c. p. [course pack] article "Teaching and Women's work", I feel like a traitor to my sex by acquiescing and becoming a teacher. I know that I will get a lot of flak for saying this but I have trouble understanding some feminists views because I have never felt all that downtrodden." (I 131)

These types of statements show students are thinking deeply about their beliefs and reconsidering previously held assumptions. These expressions also exemplify the next process goal to be discussed.

3. Developing an openness to diverse perspectives

Developing an openness to diverse perspectives is the very core of this exercise: providing a context for participants to freely exchange and consider a wide variety of ideas and potential positions which one can take on an issue. This openness is developed in at least three ways. The first is in responding to valid (or invalid) criticisms from a wide range of consultants: from conservatives to liberals, theoreticians and practitioners. One group of teachers stated clearly their perceptions of how they had grown and changed though the process:

"T 3, T 8, T 23, T 28: . . . One common criticism from the consultants identifies the teachers as neglecting to address their own biases. The fact that the "teachers" have continued to dialogue serves as just one example that this is not true. The "teachers" are open and willing to learn and broaden our/their sensitivity to these biases. As new teachers, we especially welcome and appreciate the opportunity to do this. Several teachers have amended past responses using their expanded insight." (I 102)

Many participants commented on the difficulty of trying to satisfy such a broad range of suggestions from the consultants, which is probably impossible. This exercise demonstrates one of the realities of teaching. In a sense, what one does is in the public eye, under careful scrutiny by others, and subject to varying interpretations. This helps students articulate more clearly their beliefs, which continue to develop from their initial comments about education.

A second way broader perspectives are developed among the participants is when they are playing consultant characters. In some cases, the students are playing consultants with whom they do not agree, and yet are challenged to represent the position fairly. In one case, the person playing Allan Bloom disagreed with Bloom's perception of modern students, yet was able to capture Bloom's biting criticisms of modern education, convincing in both style and content. In another case, a feminist student was concerned that her character, Sylvia Ashton-Warner, was not making forceful enough statements regarding women's rights. Although the student chose to discuss feminist issues which were not in the character's actual written work, the student was attempting to reconcile different approaches of intelligent and active women throughout this century. Again, both students were involved in learning and activating discussion within the computer conference, yet played their characters in very different ways.

A third way one's perspective is broadened is through reading and discussing with others on the same case or issues. In the following example, a teacher tries to reconcile some differing ideas about teaching dialects:

"T 52: . . . In a class I took last semester the prof. suggested that you don't have to worry about the dialectic differences, that kids will learn when each (formal/white English and Black English) is appropriate naturally. What do you think about this? If you have time I would appreciate if you could read my case study, i 121, and tell me what you think. When I first saw this case I was clueless; the issues seem so complex. But, it is very possible that I might be teaching in similar situations so these are very important to think about and discuss." (I 145)

4. Consensus building

Consensus building is, in some ways, a converse process to developing an individual position, yet is an equally important skill to practice. All participants were involved in this process in two ways: making group responses and rebuttals toward the end of the exercise, and writing about patterns of responses to the cases. Group rebuttals needed to reconcile some of the differences within the group, while individual consultants needed to make a coherent statement regarding a broad range of situations and issues. One participant described this process as follows:

"T 9: As a teacher who will soon be a consultant, I have to disagree with one point in the rebuttal. I do not think the consultants should only look at two cases. The point is to look at many items and pull them all together. It is an enriching challenge that was hard to do, but gave me a great opportunity to use a way of thinking that needed me to REALLY strech my mind and see an overview and try to pull it together . . . It sounds as if I already was a consultant but I am referring to teachers pulling points together and consultants pulling cases together as well. We both have to experience this and surface with an overview of relativity." (I 101)

In another example, a group of teachers in their rebuttal conveyed what they felt was the most useful information from the consultants:

"T 48, T 49,. T 50, T 51, T 52: Given the diversity of the consultants, it is surprising to us that much of the praise they bestowed upon our cases was rather generic. Phrases like, "Keep up the good work," and "making the best of a bad situation," did not address issues at hand as well as we would have liked. What did work was when a consultant made specific comments, as in Howard Gardner stating that he felt not enough questions were asked of the students, and how Jane Roland Martin reminded us to ask ourselves if we were teaching males and females that they are to be either emotional or logical, presuming they cannot be both.... We also feel that it weakened the impact when the consultant tried to cover all of the ground. It was most effective when the consultant stayed within their niche of expertise. B.F. Skinner, for example, stayed very true to his character ... Although we disagree with Skinner personally, we appreciate that he shared his opinions and philosophies. This was valuable in learning about different consultants and how our own teaching philosophies might be viewed by other people." (I 179)

5. Enhancement of field experiences

Another process oriented concern is whether the Diverse Perspectives exercise will enhance field experience. For conclusive evidence, we will have to wait and see; the students who participated in the exercise have not yet completed their practice teaching. There are plans to do a follow up study once these students begin their teaching careers. We can, though, see numerous examples of students struggling to apply the ideas they encounter to real-life situations. For example, one respondent to Shirley Brice Heath's role profile stated:

"T 40: I was really interested in your role profile. I have heard this problem before. I agree that just because a dialect sounds strange, that person should not be viewed as dumb or lazy. In every country, not just America, there are many different dialects. My mother tells me the form of Italian she speaks can not be understood by my Father's Mom.

The problem we face at Woodland High is quite different. It is not about discriminating against a certain dialect. Hassam has a very strong accent and frankly does not speak English very well. For this reason Mrs. Krawford will not let the child in her advanced Math class ... Please read my case and respond. I think Hassam is being cheated very badly. How can we break the communication gap." (I 113)

In another example, a student saw parallel relationships between different domains of learning:

"T 36: Anyone who read [illegible] esponse I entered last night may have noticed that I [illegible] moving in the direction of community action. Well, folks, my feelings and thoughts about Pedro, his family and the other migrant workers hit a point of near militancy this morning. I'm beginning to draw analogies between this community's relationship to the migrant workers and the traditional relationship that has existed between the U.S. and Central America." (I 166)

Clearly these students were reflecting on what they had learned and were making connections with real-life situations, which they have encountered or will encounter in the near future.

Conclusion

I have proposed that these five inter-related process goals were promoted though the use of this Diverse Perspectives exercise, and that many students demonstrated their active, cognitive involvement with the issues, both personally and professionally. Reminiscent of the image of weaving a tapestry, the components of the exercise have a strong relationship with these cognitive processes. Despite the sequential character of the exercise, these processes have a non-linear, continuous relationship with each other. One would hope for such freedom of interaction effects; the examples from the transcripts demonstrate that such interactions did take place.

The activities in the Diverse Perspective on Education exercise hold tremendous potential for satisfying specific goals in the preparation of teachers, both in content and process areas. The analysis of the transcripts provides documentation of learning among the participants. The structure of the exercise can serve both to encourage the development of particular skills and as a means of evaluating or monitoring a different range of student participation. Computer exercises should not be used at the exclusion of more traditional teaching strategies; rather, such exercises can add another dimension to teaching and allow students to express themselves and develop their ideas in a different format. This analysis has shown that this type of development is possible through the use of the Diverse Perspectives on Education exercise.

Endnotes

1. The following individuals, in addition to the authors, participated in the design and implementation of the Diverse Perspectives on Education exercise: Frederick Goodman, Ernestine Enomoto, Steve Skalka, Brian Denman, Cindy Hill, Peter Appelbaum, Helen Harrington, Shawn Lee, Edgar Taylor, Barry Martin, Mary Antony, Stella Clark, Karen de Olivaries, Stacey Marlow, Stephanie Kadel, Nancy Staub, Henry Hastings.

2. See David M. Anderson and David E. Bair, "Interactive Communications and Simulations: The Global Classroom," 1991, in this publication.

3. All quotations in this text are from the original transcripts of the computer conferences conducted during the winter and spring terms, 1990, at the University of Michigan. References to specific statements are made using "I #" for the item number on the conference. The name at the beginning of the statement is the name of the character whom the student was playing; all of these statements are from students and by no means represent the actual person whose name is used. The designation "T #" indicates that the student who made the statement was playing a teacher. We assigned numbers to the teachers to maintain anonymity.
   Spelling and grammatical errors within the statements have not been corrected; statements are precisely as they appeared on the computer conference.

The Use of Technology in Preservice Teacher Education: Reflective Practice and Self-Assessment

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Introduction

Schools of education and teacher training institutions work diligently to provide preservice teachers with both the theoretical background and practical experience they will need to provide quality education for their future students. But the education prospective teachers receive in preservice programs only prepares them as good beginners. As teachers, they must be prepared to continually assess their own performance. Formative and summative evaluation occur on a regular basis with the intent of providing objective feedback for the improvement of teaching. Test scores and achievement tests offer measures of student progress in the classroom that administrators, teachers, and the community often use to assess effectiveness. But ultimately, teachers are responsible for the assessment of their teaching, their classroom environment, and the needs and progress of their students. Preservice teachers, novice teachers, and experienced teachers all need to possess the skills and strategies that aid them in honest reflection and accurate self-assessment.

Successful self-assessment is a twofold process. The self-evaluator not only needs to perceive a need to become self-directed in instructional improvement activities, but also needs a systematic and comprehensive approach to use in self-assessment (Bailey,1981). For teachers to be successful self-evaluators they need to be proficient in self-help strategies. Bailey (1981) asserts there are three purposes of teacher self-assessment. It is intended to enable the teacher to:

- become aware of personal classroom teaching effectiveness
- learn how to control classroom instructional behaviors
- become self-directed in instructional improvement activities

Because research clearly indicates good teachers are reflective teachers who assume responsibility for student learning, methods and models must be available that enable teachers to be self-assessors of their professional effectiveness.

Many systems for recording and analyzing selected classroom events were designed in the 1960's and 1970's. These systems encouraged teachers to be more focused on certain aspects of their teaching and allowed them to reflect on the data gathered and to make thoughtful decisions concerning the data. One example is the Flanders' Interaction Analysis Categories (Flanders, 1970). This system provided a means for teachers or observers to record and analyze verbal interactions in the classroom. The analysis provided opportunity for reflection centering on such questions as:

1. How much time was engaged in teacher talk?
2. How much time was engaged in student talk?
3. When the teacher talked, how much time was devoted

to accepting students' feelings, praising, or encouraging, accepting or using students' ideas, asking questions, lecturing, giving directions, or criticizing or justifying authority?

4. When the students talked, how much time was engaged in responding to teacher initiated talk or with student-initiated talk?

The Instructional Verbal Analysis (IVA) System, a computer program system created by Dr. Todd Hoover, associate professor, Loyola University of Chicago, also analyzes verbal behaviors in the classroom. IVA is based on the original research and work conducted by Ned Flanders. IVA provides summary data that analyzes ten categories of verbal interactions in terms of ratios indicating a teacher's responsiveness to students, a teacher's dominance in the classroom, a teacher's propensity to ask questions in the classroom, and the level of student initiated talk in the classroom. IVA is useful for developing the self-assessment processes of preservice teachers. It is suitable for self-assessment because:

A. IVA provides objective summary data relative to verbal interactions in the classroom.

B. IVA can be used as a form of self-assessment without the aid of a supervisor or administrator.

C. IVA can be part of a regular, ongoing self-assessment process in the classroom with minimal disruption.

D. IVA provides a written record of the self-assessment process concerning the verbal interactions in the classroom.

Reflective Thinking and Self-Assessment

Reflective thinking leading to self-assessment is the hallmark of professional teachers. Professionals who engage in reflection are thinking deliberately and systematically about their teaching. They meditate, muse, contemplate, ponder, deliberate, reason, and speculate about their teaching (Cruickshank, 1987). Intellectually alive and reflective teachers challenge students to think critically and act creatively. Teaching is a complex activity that requires thoughtful planning and the ability to make instant decisions. Hunter (1979) describes teaching as a constant stream of conscious and unconscious decisions.

These types of reflection and decisions lead to self-assessment as Bailey defined it in 1981. He stated that the "...process of [self- assessment is when] the teacher utilizes a series of sequential feedback strategies for the purpose of instructional self-improvement" (p. 9). A basic assumption of self-assessment is that teachers can function autonomously in self-improvement activities. The purposes of teacher self-assessment are to enable the teacher to 1) become aware of personal classroom teaching effectiveness, 2) learn how to control classroom instructional behaviors, and 3) become self-directed in instructional improvement activities.

Self-assessment techniques commonly employed by teachers include individual assessment, feedback assessment, and interactive assessment. Typical individual assessment strategies are personal reflection, analysis of classroom tapes, and self-assessment checklists. Feedback to facilitate self-assessment may be obtained from students, peer teachers, or supervisory staff. Clinical supervision and microteaching are examples of interactive assessment techniques (Iwanicki & McEachern, 1983, p. 67).

Personal reflection, the most widely used approach to self-assessment, is valid only to the extent that teachers have an adequate grasp of the concepts affecting the teaching-learning process (Iwanicki & McEachern, 1983). Although the empirical evidence for the effectiveness of self-assessment in promoting teaching improvement is not great, "self-assessment is essential because one cannot improve one's teaching until personal deficiencies are recognized and the need for change internalized" (Rippey, 1981). Self-assessment is most effective when one method is used in conjunction with another and when each method is based on specific criteria agreed upon in advance.

Self-assessment as one way of promoting professional growth is supported by theoretical and empirical investigations. Hall's (1979) work delineating the dynamics and stages of change, and Fuller's (1969) research focusing on affective dimensions of teacher growth, suggest the importance of individual involvement in the development process. Allowing and encouraging teachers to assess their own instruction and to decide themselves which areas they would like to improve clearly puts teachers in control.

Accurate self-assessment is difficult for student teachers, yet it is vital for them to be able to objectively assess their own classroom interactions so the adjustments and alterations beneficial to themselves and their students can be made. In the project discussed here two techniques are used to help student teachers develop skills in self-assessment.

Helping Student Teachers Develop Skills in Self-assessment.

Loyola University student teachers are required to keep a student teaching journal as one means of assessing their student teaching experience. These journals serve as outlets for thoughts, feelings, ideas, and reactions that generally focus on specific areas of interest and/or concern to the student teachers. They are read periodically throughout the semester by the university supervisors and Director of Teacher Education and provide one effective path to self-assessment. But, as previously indicated, a variety of self- assessment strategies brings both balance and objectivity to the self-assessment process.

At second technique employed at Loyola University is the Instructional Verbal Analysis System (IVA). Student teachers use the system to obtain accurate feedback concerning the verbal interactions in their classrooms. IVA provides objective data for use in the self-assessment process. It is designed to analyze the following ten categories of verbal interactions occurring in classrooms:

1. Clarifys/Answers Questions
2. Praises or Encourages
3. Accepts/Uses Ideas of Learner
4. Asks Questions
5. Lectures/Gives Information
6. Gives Directions/Organizes
7. Learner Responds to a Specific Question
8. Learner Initiates Own Comment or Response
9. Learner Asks Questions
10. Silence or Confusion

These categories align into three distinct groups. The first group (categories 1 to 6) is teacher talk. The second (categories 7 to 9) is student talk. The final item (category 10) indicates the classroom is in a state of silence or confusion.

IVA analyzes these categories and provides feedback about verbal teaching behavior interactions in terms of four specific ratios:

RR = Response Ratio
DR = Dominant Ratio
QR = Questioning Ratio
IR = Initiative Ratio

These ratios provide a numeric representation of the verbal interactions that occur in the classroom. They can be an indicator to students of areas of strength and weakness relative to classroom verbal interactions.

Research Process

In this study the effectiveness of the IVA in facilitating students self-assessment skills was evaluated. Students used an audio cassette tape recorder to tape selected teaching sessions. Within twenty-four hours of the audio taping, students listened to at least fifteen minutes of the teaching session and every three seconds recorded a number corresponding to one of the ten possible verbal behaviors. These numbers were then fed into the IVA computer program that summarized the data and presented ratios that represented classroom verbal interactions. The students coded five separate teaching sessions. In addition, the university supervisors were responsible for audio taping and coding three teaching sessions for each of their assigned students. The analysis from the first supervisor audio tape were completed during the first four weeks of the student teaching experience, the analysis from the second supervisor audio tape were completed before week nine of the student teaching experience, and the third audio tape were completed during the last three weeks of the student teaching experience.

The student teachers each audio taped and coded five of their own lessons. The audio taping schedule was as follows:

Tape #	Recorder and Coder	Week due
1	University Supervisor	five
2	Student teacher	six
3	Student teacher	nine
4	University supervisor	nine
5	Student teacher	eleven
6	Student teacher	twelve
7	Student teacher	thirteen
8	University supervisor	fourteen

During the week the audio taping and coding were due, students met for seminar in the assigned computer center and for the first fifteen minutes of seminar implemented the IVA program to obtain data concerning their lessons. After assessing the data, the student teachers responded in writing to a set of questions concerning the teaching episode and the resulting data.

Bi-weekly seminars were held to aid the students in increasing their abilities to improve their own teaching behaviors. Seminar topics included questioning strategies, use of positive reinforcers, use of advanced organizers and effective means of closure, and lesson plan organization and implementation. In addition, the seminar students viewed four videotaped teaching sessions, practiced coding those teaching sessions, and discussed the results of the codings with an IVA expert. Students also viewed two fifteen minute teaching sessions while an IVA expert coded those teaching sessions. Immediate feedback using the data from the IVA expert's codings were the basis for discussion of the verbal interactions as well as how teaching strategies could be altered to change the verbal interactions.

The university supervisors were trained to use and implement IVA during an all-day six-hour workshop held prior to the opening of the semester. During this training the supervisors were given multiple practice sessions to code correctly and to interpret verbal interactions and resulting ratios accurately. Two one-hour follow-up training and reinforcement sessions followed during the semester. Supervisors' audio tapes were randomly chosen to be coded by an IVA expert. The correlation between the IVA expert codings and the supervisor codings was approximately .78.

Results

Table 1 contains data indicating significant differences between audio tapes four and audio tapes eight. Although 31 student teachers participated in this study, 28 of the students had complete data for audio tapes one, four, and eight (criterion weeks).

Significant differences were found between audio tapes four and audio tapes eight for RR, DR, and IR at the .05 alpha level. No significant differences were found between audio tapes one and four and between one and eight. ANOVA indicated there were no significant differences between ratios of student teachers assigned to kindergarten through third grade, fourth through eighth grade, and ninth through twelfth grade.

During the first nine weeks of the student teaching seminars student teachers concentrated on learning the IVA system, perfecting accurate coding of actual and videotaped teaching episodes, and analyzing the IVA ratios. Between weeks nine and fourteen, student teachers assumed full teaching responsibilities for a minimum two week period for their assigned teaching day in their classrooms. The student teachers audio taped, coded, and analyzed three more of their own teaching episodes during weeks nine and fourteen. Student teacher seminars during weeks nine and fourteen focused on appropriate lesson planning, effective teaching strategies, use of positive reinforcers in the classroom, use of advanced organizers and appropriate closure, and ways to initiate student talk in the classroom.

During weeks nine and fourteen the student teachers struggled with all aspects of teaching — their responsibilities included daily lesson planning and presentation, unit planning and presentation, test preparation, and grading. They also began to take full responsibility for classroom discipline and assumed playground duty, lunchroom duty, and study hall duty as well. During these six weeks they endeavored to utilize a variety of effective teaching strategies in their classrooms and to engage in reflective thought and self-assessment through their required journals and with IVA.

Conclusions

IVA data provided an objective, nonthreatening indicator of the verbal interactions and general teaching strategies employed in the student teachers' classrooms. Analysis and discussion of the IVA data of their own teaching episodes in seminar provided opportunities for reflecting on the types of changes needed in teaching strategies to have a more interactive classroom during weeks nine through fourteen. The emphasis on using the IVA categories and ratios in the student teacher seminar and the students increased familiarity with interpreting the statistical data provided by IVA may also account for the significant differences in ratios between weeks nine and fourteen of the student teaching experience. The more comfortable and confident the student teachers became in the classroom, the more they were willing and able to respond to the students in their own classrooms, be less directive, and to encourage a more interactive classroom. This is reflected in the significant changes in the RR, DR, and IR ratios from weeks nine to fourteen.

IVA is an appropriate self-assessment tool for student teachers if certain criteria are met. Based on the research protocol, the following suggestions are made to enhance the effectiveness of IVA with student teachers:

1. Effective teaching strategies should become an integral part of methods classes at both the elementary and secondary level.

2. IVA can be introduced in the methods classes at both the elementary and secondary level.

Table 1

Paired Samples t-test Results for Audiotapes 4 and 8

	AUDIOTAPE 4		AUDIOTAPE 8			
RATIO	MEAN	S.D.	MEAN	S.D.	t-value	SIG
RR	18.82	8.25	23.74	11.9	2.063	.049
DR	80.18	8.25	75.29	12.02	2.048	.050
QR	40.46	20.83	42.16	22.10	.514	.611
IR	30.71	26.22	39.9	26.05	1.979	.058

3. IVA categories are internalized through practice and discussion in the methods classes at both the elementary and secondary levels.

4. Students should perfect coding skills prior to student teaching.

5. Students should analyze numerous teaching sessions using IVA prior to student teaching.

6. Students should participate in simulated teaching sessions with IVA and engage in analysis and reflective thinking concerning the IVA ratios prior to student teaching.

7. Student teachers should assume responsibility for audio taping, coding, and analyzing at least five teaching sessions during the student teaching experience.

8. Student teachers should engage in one-on-one discussions with university supervisors using IVA data as a basis for discussing characteristics of their classrooms.

9. Supervisors, trained and proficient with IVA, should utilize IVA data for formative evaluation of student teachers.

10. A component of the student teacher seminar should consists of both large group and small group discussion of IVA data and ways to enhance interactive teaching in the classroom.

11. Audio taped teaching sessions should be at least twenty minutes in length when appropriate.

12. Selected audio taped teaching sessions should be repeated with the same students in the same discipline with a similar teaching format so student teachers can focus on implementing effective teaching strategies to alter verbal interactions in the classroom.

13. A criterion measure should be administrated during the first and last week of the student teaching experience.

14. Data should be collected from student teachers audio taping and coding their own teaching session during the beginning of the student teaching experience and again near the end. If these audio tapes of the same students are in similar disciplines with similar class formats, the IVA data will be a more accurate assessment of the student teachers' abilities to alter verbal behaviors for a more interactive classroom.

Summary

Clearly, the use of the microcomputer with appropriate software can substantively enhance the outcomes from a teacher education program. However, the computer and software are not, in themselves, sufficient. The success is dependent on implementation that is appropriate and sufficiently regular. The combination will then result in a teacher who is reflective and who is basing reflection on objective self-assessment data.

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Conceptual Foundations of Statistics: A Constructivist and Technological Approach

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Introduction

In his State of the Union Address (January 29, 1991) President Bush reiterated his national goal that by the year 2000 America's students should be first among the industrialized nations in mathematics and science. Two notable documents, the National Council of Teachers of Mathematics (NCTM) "Curriculum and Evaluation Standards for School Mathematics" (1989) and "Everybody Counts" (Steen, 1989) have set forth sweeping recommendations for mathematics education reform. Based on recent developments in cognitive psychological research, and supported by the largest organizations for mathematics teachers and professors in the country, these documents present a new vision for the mathematics classroom. The "Standards" advocate students' active collaborative involvement with mathematics in place of silent, solitary paper-and-pencil drill. The development of generalized problem-solving skills is considered more valuable than the mere memorization and application of procedures. The use of calculators and computers is recommended for all grade levels. Teachers support students' development as mathematical thinkers, preparing them to be life-long learners.

This paper will briefly describe the SummerMath for Teachers P gram at Mount Holyoke College and the constructivist philosophy upon which the program is based. Ways in which technology can support constructivist mathematics instruction are discussed. The SummerMath for Teachers course, "Conceptual Foundations of Statistics," provides a concrete example of how technology and a constructivist approach can be combined to create a dynamic learning experience for teachers.

The SummerMath for Teacher's program

For nearly ten years, the SummerMath for Teachers Program at Mount Holyoke College, South Hadley, Massachusetts, has introduced teachers to a constructivist approach to mathematics instruction, a philosophy of education that is very much in harmony with the vision presented in the NCTM "Standards". Through summer institutes, mentor teacher support, workshops, semester courses, and materials development, SummerMath for Teachers works to provide teachers (grades K-12) with opportunities to strengthen their mathematics background and to re-evaluate and improve their teaching approaches.

The program has secured three major grants from the National Science Foundation (NSF), The Educational Leaders in Mathematics (ELM) Project (1986-1988), the Mathematics Leadership Network (MLN)(1988-1991), and the Mathematics Process Writing Project (MPWP) (1990-1993).

The Constructivist Approach

Constructivism provides a theoretical framework for mathematics education that takes into account how students' conceptual understanding develops. The core principle is that real understanding is achieved when learners construct their own ideas rather than passively absorbing or copying those of others. Those who embrace constructivism reject the notion that a teacher is able to transfer his or her understanding to passive learners who incorporate exact copies of the teacher's understanding for their own use (Fosnot, 1989). Students' understanding of a new mathematical concept depends upon their linking that concept with past knowledge solidly understood. The student must actively engage problems and concepts in order to make connections and build structures of understanding (Mundy, Waxman, and Confrey, 1984).

Teaching mathematics means providing students with the opportunity, and the requisite stimulation, to construct powerful mathematical ideas for themselves, to guide them in that process, and to help them know their own power as mathematical thinkers (Schifter and Simon, in press). The teacher is no longer the teller but the creator of problem-solving situations. The teacher must select tasks which are grounded in real world experiences or mathematical objects well known to the students, enabling them to build on already present cognitive structures. The teacher must balance the interest and questions generated by the students with the goals of the curriculum (Simon and Schifter, in press).

A Role for Technology in the Constructivist Classroom

Active involvement, exploration, and discovery are keys to the constructivist approach to learning. Computer software such as The Geometric Supposer, The Algebra Supposer, The Function Analyzer, Elastic, ChancePlus, and a host of basic statistical computing packages allow students to manipulate mathematical objects (here data sets are mathematical objects) and to actively explore mathematical realms. Students' discovery of patterns, contrasts, and exceptions, can lead to the construction of their own hypotheses. With the aid of the computer, students can tackle problems of a more complex nature. Problems no longer need to be so oversimplified and "clean" that they lose all connection with reality.

Conceptual Foundations of Statistics

To realize the goals set forth by the "Standards," teachers must re-evaluate what they teach as well as how they teach. As we move into the Information Age, it becomes increasingly important that our next generation understands how to interpret probabilistic and statistical information (Steen,1989). In addition, since many basic concepts of mathematics are used in probability and statistics, these subjects can serve to reinforce students' understanding of basic mathematical concepts (Goldin, 1990). For these reasons The NCTM "Standards" recommends that probability and statistics be included as part of the mathematics curriculum, K-12. Since teachers have had very little formal instruction in probability and statistics, SummerMath for Teachers has developed the course "Conceptual Foundations of Statistics" to aid in making this recommendation a reality.

Course Description

Teachers (K-12) are given the opportunity to role-play as statisticians. Teachers must formulate questions, collect, explore, and analyze data. In place of lectures, problem situations are presented and the class is divided into small groups to attack the problems. Whole-group discussion is used to share experiences and learning. The class works to resolve questions and to pose new directions for further investigation. Articles are assigned to supplement the in-class work and discussion.

Material for this course has to engage teachers' interests as adult learners. Additionally, it must be adaptable for use with students of different grade levels. (The "Used Number Series" (1990) and the "Quantitative Literacy Series" (1987) have proved to be useful resources from which to draw such material.)

A number of lessons are based on class-collected data sets. Class-collected data is valuable for grounding abstract statistical concepts in concrete experiences and "...familiarity suggests both expected features to look for and explanations for unexpected features" (Moore, 1990, p. 112). Real data is inherently "messy," a condition which often leads to different interpretations. Students' work is judged according to how well they have communicated features of the data that support their conclusions (Russel & Friel, 1989).

Teachers, guided by worksheets, spend one-third to one-half of class time on computers working with the statistical computing package MINITAB. With MINITAB, data can be easily manipulated for exploration and analysis. Since the program is able to construct visual displays quickly, there is more time to look at multiple representations of the data and to interpret both graphical and numeric information. Moreover, this software allows data to be pulled apart and pushed together for viewing from different vantage points.

The following example, "When the Chips are Down," shows how assigned readings, problem situations, small-group and whole-group discussions, class-collected data, and computer work are woven into a cohesive unit.

"When the Chips are Down": An Example

I brought three bags of chocolate chip cookies to class and posed the question: What would you like to know about these cookies? After a fair amount of discussion, the teachers decided that they wanted to know which brand of cookies had the highest average number of chips per cookie. The discussion went something like this:

Teacher #1: Chips Ahoy advertises that it has more chips than the other leading brands. So, I want to know if that's true.

Instructor: I'll give you a cookie from each of the brands then you tell me the answer.

Teacher #2: No, because a different cookie in the package might have a different number of chips.

Instructor: That's variability. Different cookies may have different numbers of chips in them, even with the quality control at, say, Nabisco, which makes Chips Ahoy cookies.

Teacher #3: Let's find the average number of chips per cookie for each of the three bags of cookies.

Instructor: My undergraduate class conducted the same experiment. Do you think you'll get the same averages from your bags of cookies that they did?

From here we entered into a discussion about the population mean versus a sample mean. The class decided they wanted to know whether the population means for the three brands of cookies were different.

One cookie was passed around the room and each teacher counted the number of chips. Due to variability in counting procedures the results ranged from 12 to 28 chips for that single cookie! A heated debate ensued over a standard procedure for counting. Two cookies had to be sacrificed so that the teachers could count "exactly" how many chips were in a cookie — only to find that they still had to decide what to do with partial chips. It was finally decided to count the chips appearing both on the top and the bottom of the cookie; if a chip were on the edge it was counted only once. Small flecks were not counted. Two independent counts were taken on each cookie as a check.

The data collected by the teachers, together with that collected from the undergraduate class, was entered into a MINITAB worksheet. A small portion of the the undergraduates' data is shown below (there were another six columns of data from the teachers' experiment):

ROW	ahoy1	ahoy2	aroo1	aroo2	big1	big2
1	10	10	16	15	20	15
2	19	19	14	12	21	15
3	15	17	19	17	23	16
4	13	16	13	12	11	10

Initially, the teachers posed only the one question about comparing the average number of chips per cookie for the three brands. But after viewing the data from the experiment the teachers, working in pairs, started to pursue the additional problems listed below:

1) Evaluation of the reliability of the counting procedure.
2) Characterization of the distribution of cookie counts within a single brand of cookies.
3) Comparison of chip counts for the three brands of cookies.
4) Comparison of the reliability of the counting procedure between the two classes.
5) Comparison of the results for the two classes.
6) Combining information from the two classes in order to get better results for #3.

During analysis of the data teachers did not know how to calculate the overall mean from the two classes' sample means. (The two classes averages were based on substantially different numbers of cookies.) Initially, teachers did not realize that they were dealing with a weighted means problem, a subject dealt with in a previously assigned article (Pollatsek, Lima, & Well, 1981). During a subsequent whole-group discussion, the tie-in with the article was made and several solutions were worked out.

Data consisting of two counts per cookie for six bags of cookies would have been very tedious to analyze by hand. Comparative dot plots, histograms, and box plots provided visual representations of how the chip counts differed among the three brands and between the two counts. Basic descriptive statistics of location and dispersion were compared.

Conclusion

Requiring teachers to take more traditional-style courses does not produce better teachers (Hyde, 1989) and offers little contribution toward realizing President Bush's educational goal for mathematics primacy. Simply using computers as mechanical drill-sergeants is equally shortsighted. Teachers need a broadened vision of what constitutes mathematics and statistics. They also need opportunities to experience alternatives to traditional mathematics instruction. Mount Holyoke's SummerMath for Teachers Program serves as a successful model that incorporates technology, applies a constructivist philosophy to teaching, and supports teachers in their efforts to deepen their mathematics background.

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Instructional Strategies in Facilitating Innovation-to-Practice

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Astonishing advances in microchip technology are profoundly changing the nature of what needs to be learned, who needs to learn it, who will provide it, and how it will be provided and funded. Schools, colleges, and universities face the challenge of getting teachers, education professors, and students to use this technology.

Some educators have argued that schools are lagging in integrating technology (Gooler, 1989). Current studies also report that there has not been widespread use of technology in classrooms (U.S. Congress, Office of Technology Assessment, 1988). On the topic of computers in the schools, Wagschall (1986) raises a major dilemma: "... no one has a good conception of what teachers 'should' be doing with these machines in their classrooms. As was the case with television in the '50s, we seem to have purchased a new technology without first figuring out how we can train people to use it in their day-to-day activities. We should not be surprised, then, to find that the technology gets used less with each passing day." (p. 33).

One reason schools are behind other organizations in the integration of technology is that teacher education programs have been slow in their integration of computers and in instructing teachers how to use technology (Axler-Turner, 1989; Glenn and Carrier, 1989; U.S. Congress, Office of Technology Assessment, 1988). Primary factors in this scenario are the education professors who are the vital links in the preparation, induction, and inservice of teachers. Some individuals argue that education faculty themselves are not adequately prepared to prepare their students for an increasingly computer-dependent society (Podemski, 1981).

One solution, advocated widely in the professional literature, involves conducting workshops to reeducate teachers. The intent of these workshops is to raise awareness and skill levels, change attitudes, and/or prepare individuals as change agents. This is a common illusion. It is unrealistic to expect that a few days of workshops are sufficient for preparing faculty to effectively integrate computer technology into classrooms and into their repertoire of tasks. It is also unrealistic to expect that the anxiety, apprehension, procrastination, and fear over using microcomputers will dissipate through a prescriptive, brief encounter. Many workshop programs typically designed to improve the computer knowledge or skills of faculty fail to result in significant, lasting, new behavior when participants leave the sheltered environment of the workshop and return to their real work classroom environment.

Some faculty feel encumbered by having to learn new behavior and may perceive microcomputers as being disruptive to their preferred and customary way of functioning. They may attend mandated workshops with reluctance or even avoid attending.

Understanding why some innovations succeed while others fail involves examining how individuals adapt to innovation. The individual is a pivotal and powerful player in the process of planned change. Some individuals enjoy, even savor, the experience of becoming impresario over the machine. Others find it a troublesome, stressful, and even fearful experience.

This paper discusses how to make faculty instruction more effective. A naturalistic method of inquiry was used to study how six faculty in a school of education adapted to their microcomputer in their office (Yessayan, 1991). Several emergent theories, grounded in the data, indicate identifiable patterns of adaptation to innovation. In addition, differences and commonalties in the background of individuals that may be contributing factors in the use of microcomputer were identified. Although the instructional strategies discussed in this paper are based on emergent theories of how faculty at the university level adapt to technological innovation, they have relevance and transferability to how teachers in schools adapt to microcomputers.

Understanding Individual Adaptation

The emergent theories developed from the author's findings are tentative. These are presented to provide the basis for discussion about instructional strategies which facilitate individuals' incorporation of microcomputers into their own practice. In the model proposed here, adaptation is conceived of as a process in which individuals react, are affected by, and influence the course and nature of innovations in dynamic, organic and complex interactions. The term 'readiness to adapt' means having a tolerance for innovation. It appears to have three dimensions, namely: (1) "the sequence" of adaptation over time (the order/progression by which innovation is tolerated); (2) "the rate" of adaptation over time (the speed in which it takes individuals to tolerate innovation); and, (3) "the duration" of adaptation over time (the length of time over which an innovation is accepted by individuals). Each will now be discussed.

Sequence

At the sequence dimension of readiness, individuals speculate on the significance and the importance of an

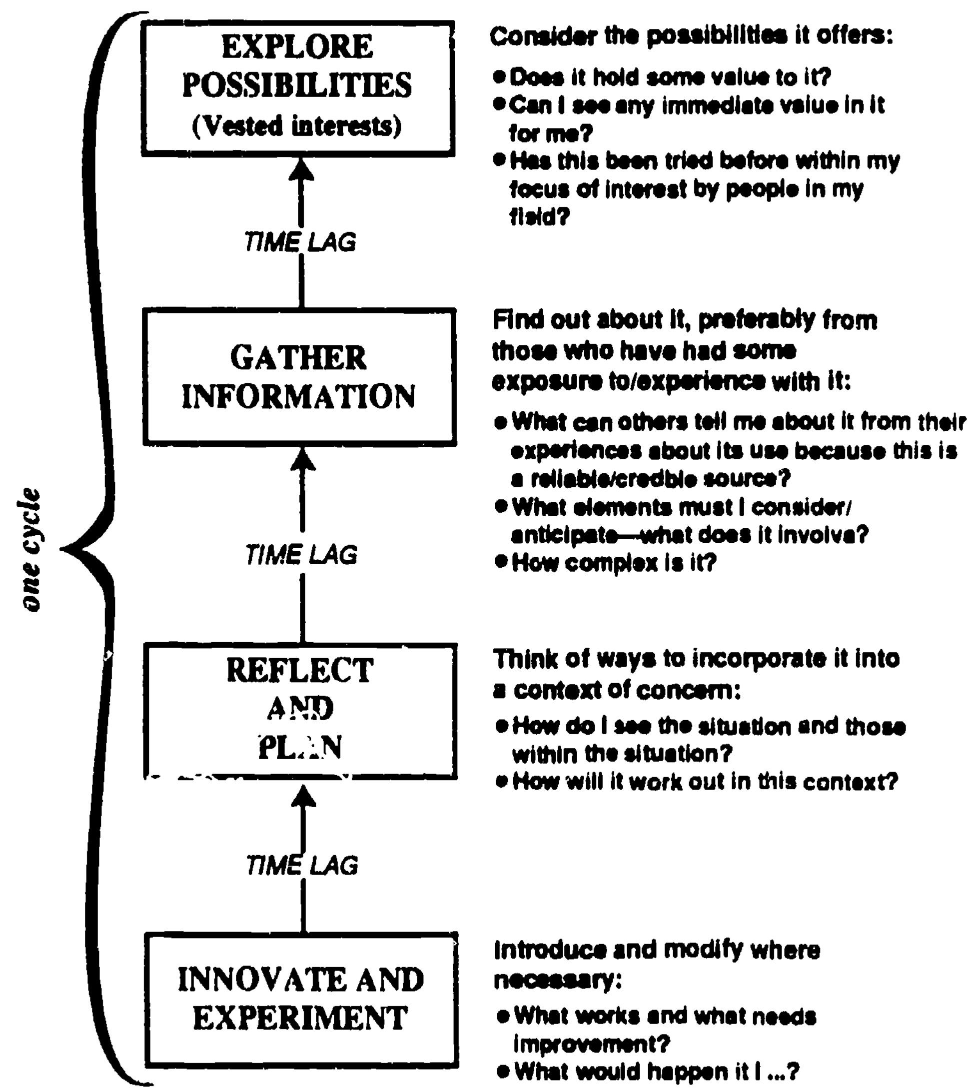

Figure 1: Innovation-to-Practice Process (I.P.P.)

innovation. They focus on how an innovation will affect them personally, how much effort it will take to adapt to an innovation, and how this will effect existing ways of functioning in their field. There are four possible phases in how individuals reflect about innovation. These phases are displayed in the Innovation-to-Practice Process (I.P.P.) model (see figure 1). Examples of the type of concerns at each phase can be observed in the type of questions frequently posed.

First, a person considers the potential of the innovation in helping to meet an unresolved problem or need. This has been identified as the "Explore Possibilities Phase". An interval of time (a time lag) results between each phase and cycle in the process. This time interval varies from individual to individual depending on their cultural context and formative experiences.

At the second phase, the "Gather Information Phase," an individual will journey on a search for information about the innovation. Credible or reliable sources of information are influential in terms of encouraging or deterring the individual toward subsequent phases and cycles. Once at the "Reflect and Plan Phase", an individual will size-up the situation and think of ways to incorporate the innovation into the contours and configurations of their cultural context.

At the final phase of a cycle, the "Innovate and Experiment Phase," individuals will take steps to introduce, and then modify, the innovation. Subsequent cycles in any of the four phases may be entered depending on how far individuals proceed with using the innovation.

Rate

The rate dimension of readiness refers to the speed it takes individuals to move along a continuum of types of sequences of use over time, namely from Previous Use to Initial Use to Repeated Use to Protracted Use. Interestingly, individuals fluctuate between different sequences of use. The Developmental Progression in the Adaptation Process model (figure 2) displays how formative experiences over time contribute to how quickly individuals move between different sequences of use. This progression of movement occurs in a different pattern for each individual. Individuals can return to a previous sequence of use, move to the next plateau of use, or remain stagnant at a plateau of use.

Duration

Mischel (1984) espouses that adaptive behavior needs to occur over time and across occasions in identical or nearly identical situations in order to see consistency in adaptive behavior. His theory contributes to the third dimension of 'readiness to adapt' namely, "the duration". Duration refers to the length of time an innovation is accepted by individuals.

Implicit in this concept of readiness to adapt are two premises. First, individual adaptation to an innovation

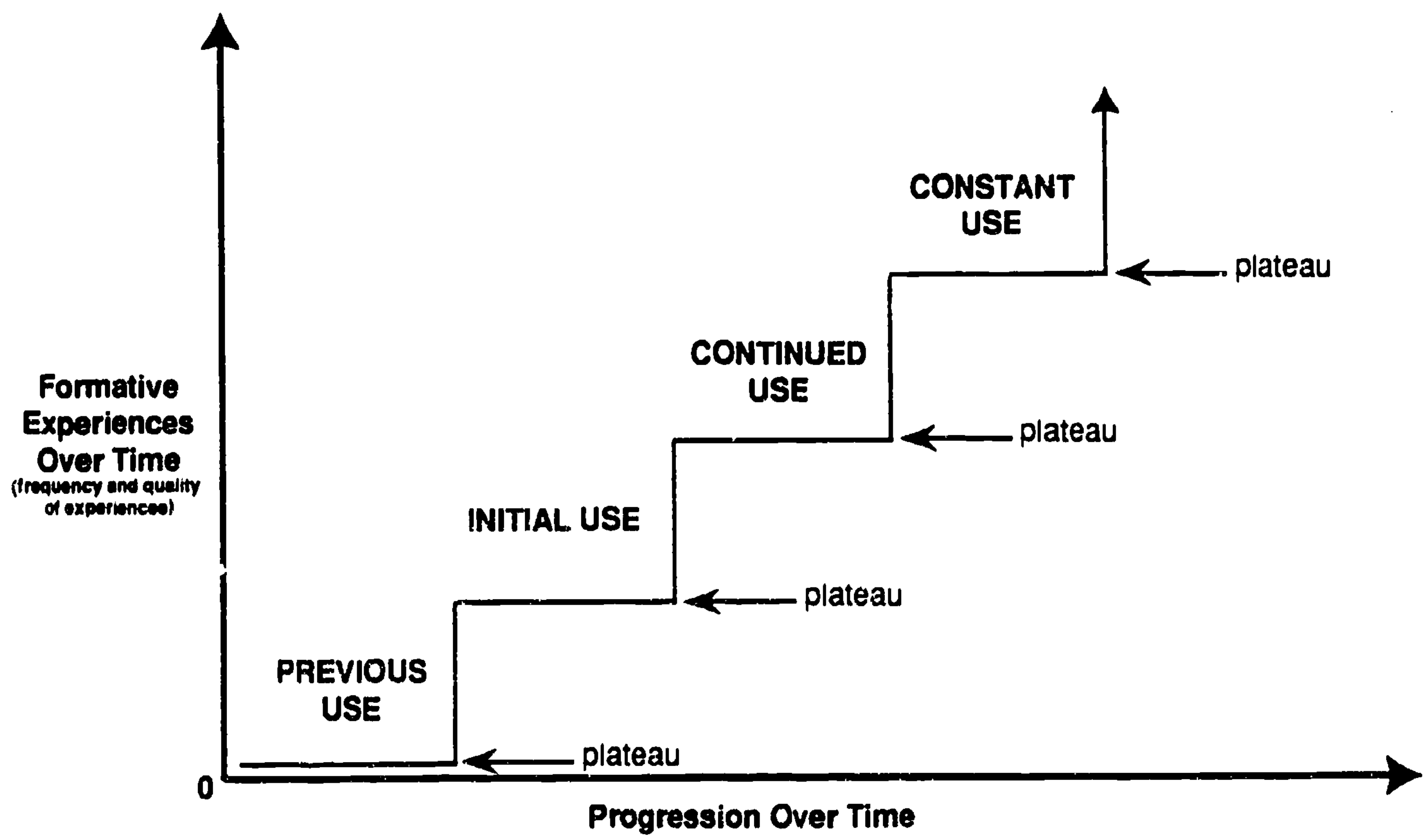

Figure 2: Developmental Progression in the Adaptation Process

has an cumulative dimension. One needs to observe individuals' adaptive capacity over time to capture the consistency of their behaviors. Second, the readiness of individuals to adapt is multifaceted and involves a dynamic, organic, and complex mutuality of interplay between individual and innovation. Therefore, it is likely that one must look at dimensions of the sequence, the rate, and the duration to understand how individuals adapt to microcomputers. As one can see, readiness in individual adaptation is a complex and tentative schemata with multidimensional parts that offers evolutionary understandings of how faculty adapt to microcomputers.

Instructional Strategies

Computer instruction may need to be designed to address an individual's readiness to adapt. Individuals need to be at a place and time where they are ready to tolerate learning new behaviors. A set of supports needs to be established to increase an individual's level of tolerance for learning how to integrate microcomputers into their classroom instruction. Ultimately however, teachers will personally decide whether any technological innovation is worth their investment of time and energy.

The frequency of performing tasks on a microcomputer over and over builds expertness. Also, problem-solving independently and humanizing vicarious experiences improve the participant's expertness with microcomputers. This was supported in the findings of the study reported here (Yessayan, 1991). The nature of an individual's formative experiences and cultural environment are vital considerations in understanding how to design computer instruction. The formative experiences of individuals have two emerging characteristics. They are frequency and quality. The constructs for each will be briefly discussed.

Frequency

In examining differences and similarities in the way individuals use microcomputers, two dimensions of frequency emerged. They are repetition and variation.

Repetition. Individuals need to be provided with frequent opportunities to practice on tasks they are likely to use in their real work environment. In this way, they can be expected to assume more responsibility for making their own educational experience a meaningful and useful one.

Variation. Practice using different types of computer systems (whether Macintosh or IBM) and software also contribute greatly to strengthening individuals' skill level. Additionally, individuals need to perform a variety of activities using software packages. Learning to use different ways of performing the same activity increases confidence and adds to the repertoire of their skills. These experiences should be relevant to the individuals' real work situation. Repetition and variation as dimensions of frequency of use need to be tailored for each individual for meaningful learning of new behaviors to occur over time.

Quality

The second emergent dimension of people's formative experiences is quality. Problem-solving and vicarious experiences were identified components of the quality dimension.

Problem-solving. Participants especially competent with at least one software program spoke of incidents where they were directly involved in problem-solving on their own which required some risk taking in exploration. Experimentation with software application programs enhanced their commitment. Often these type of situations arose as a result of either choice in wanting to be self-taught or no choice because no-one more knowledgeable about the system was around to assist when problems occurred. Individuals with a low tolerance for ambiguity and unsuccessful attempts at problem-solving may be more likely to give on the technological innovation. Therefore, there needs to be support for experimentation.

Faculty should be allowed to take their computers home. There also needs to be a resident consultant (someone familiar with computers and their operation) available to work with faculty on an individualized one-to-one basis, to help assess needs, and willing to help faculty determine how to effectively integrate computer technology into their instruction.

Vicarious experiences. In addition, several participants presented scenarios of a series of experiences that were of a vicarious nature. These vicarious experiences were described as having humanizing characteristics that enriched the quality of their exposure to microcomputers. Usually the characteristics of humanizing experiences occurred through informal discussion with peers (who were willing to share their computer knowledge) in the work environment. In these types of vicarious situations, the individual had an opportunity to see immediate advantages in using a microcomputer to accomplish some work on which his/her energies were currently focused. And usually these vicarious experiences resulted within the framework of individualized, one-to-one instruction.

Summary

In order to make instruction work, it is necessary to understand how individuals adapt to technological innovation. The tentative models presented here suggest that individual readiness to adapt to technological innovation is multifaceted and complex. The design, content and duration of computer workshops or training programs need to assist individuals in building their formative experiences over time through repetition, variation, problem-solving, and vicarious experiences.

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Computers and Cooperative Learning: A Background for Teachers

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Introduction: Computers and Cooperation

Although both computing and cooperative learning have been gaining popularity in schools for years, the two movements have not necessarily had much to do with one another. They are similar in that they are both classroom innovations that may force educators to think differently about some aspects of classroom organization, structure, roles, or curriculum. On the other hand, the differences between them have been significant. While cooperative learning is based on a view of how students learn, computers have been seen as general tools, meaning that they could be used for one thing or another, to reinforce whatever approach to learning teachers used. In many cases, moreover, computers were removed from classrooms and isolated in labs, frequently severing any connection between computing and classroom activity.

A more general problem with computers has been that they were originally viewed almost universally as tools for individuals, and this perception has persisted. While some educators have seen all along the possibility and desirability of attaching cooperative work to computing, only in the last few years has this approach become articulate in terms of research and practice.

Research on cooperative learning has shown generally positive effects on learning and attitudes (Slavin, 1985), and the notion of cooperative learning has by this time circulated widely throughout education. Accordingly, many computer-using teachers have begun to think about connecting computers to cooperation. In a recent study of New York City public school teachers who said they used computers for cooperative learning, we found that almost none of them had any training or background knowledge of the theory or practice of cooperative learning as articulated by educators involved with this approach (OREA, 1990). The desire shown by these teachers, and the effort they expended, mostly without any preparation or help from educators around them, to introduce collaborative computing to their students highlights the necessity of teacher education in this area.

The goal of this paper is to outline a background that will enable teachers to use computers effectively for cooperative learning. The topic is complex. It involves theoretical and practical learning, knowledge about technology, as well as knowledge about cooperative learning. Therefore, the background I envision would not necessarily be contained in a single course, but possibly in several, and ideally spread throughout many areas of teacher preparation. The elements of such a background include:

1. an understanding of how technology has interacted with our culture to help produce and maintain an individualistic bias toward learning;

2. a familiarity with the potentials of modern technology and how it has helped influence trends toward greater cooperative decision making;
3. a thorough grounding in principles and practices of cooperative learning, and;
4. the opportunity to use and become expert in computer applications that lend themselves to collaborative problem solving, together with the chance to model collaborative use of such applications.

The first two elements involve an examination of technology's relation to our society and history that is usually ignored in teacher education. yet I contend should be regarded as essential. This is because, as the next section tries to show, technology has helped shape our world and our perceptions of how we learn and wi'' continue to do so. An understanding of the forces involved should inform the practice as well as the content of teaching. Teacher education has tended too much to divorce theory from practice, choosing instead to train teachers in techniques of implementation, and a step toward reversing this trend should be the realization that the trend itself is partly an artifact of technical thinking.

Thus, this paper seeks to combine theory with practice. It outlines a background in how technology has influenced learning, and argues that while technology's bias has nearly always been individualistic, recent trends in technology and society encourage a collaborative use of technology. Next, it presents the essential principles of modern cooperative learning theory with a view toward looking at a set of models of software practice that embody cooperative learning. It argues that technology can be used either to encourage an individualistic and mechanical approach to learning or to foster a collaborative and problem solving approach, and that to use technology effectively teachers must be armed with an education that empowers them to make informed decisions about technology.

Technology and Cooperation — Two Trends

Changes in technology are interrelated to other developments in society. It is important for teachers to understand that technology has played, and is still playing, a critical role in the way we think about our world, how we organize societal institutions, how we communicate, and how we think about learning. In this light, this section outlines the growth of two major trends in our conceptions of how technology should be used.

Mechanization and Individualization

Technology affects society in countless and contradictory ways, bringing improvements to health care as well as the potential for mass destruction. The changes that technology helps bring about lie not only in material objects but also in the way we think about the world. The invention of mechanical clocks in medieval Europe, for instance, began a process of routinizing our lives (Mumford, 1962/1934). The Scientific Revolution was based on a further mechanization of the world picture, the idea that the world could be seen as a collection of particles interacting with one another (Burtt, 1954). Descartes' and Galileo's analysis of the world into discrete and presumably measurable elements led not only to the foundation of the physical sciences but also to efforts to analyze human society along scientific lines. Just as the universe is composed of atoms bumping against one another, thinkers like Hobbes and Locke reasoned, human society is made up of atoms (in this case people) in perpetual motion and natural conflict. In these terms, the problem for government is to devise ways to keep people from conflict. The natural state of society is a war of all against all, in which individuals strive for power and maximum gain (Barber, 1984).

The foundations laid by these ideas centuries ago form the basis of what we call the liberal state, the goal of which is to find methods of protecting the rights of individuals vis a vis other individuals (Sullivan, 1986). Thus our political and economic thought, modeled after scientific analysis of the universe, is grounded in individualism and competition. Instead of assuming that the natural human state is cooperation, the major institutions of our society assume the opposite. Our schools, of course, have shared the same assumptions. Throughout the history of American schooling, with few exceptions, educators have viewed students as individual vessels, originally empty, to be filled with knowledge (Locke's image), naturally competing against each other for prizes or praise (Johnson and Johnson, 1975).

Not surprisingly, then, technology has been seen almost exclusively as a tool in the service of individualism. First, all tools in the educational arsenal are naturally used to enhance existing educational practices. More significantly, though, technology has provided the means of promoting a mechanical type of individual treatment. John Dewey, at the beginning of the century, saw that the older self-reliant type of individualism he associated with growing up in a small town where everyone knew everyone else was giving way to a newer kind of individualism based on what Dewey called "corporatism" (Dewey, 1930). The emergence of an urban society in which masses of people interacted in impersonal ways, coupled with the growth of corporations and other societal institutions which linked people in new ways, without face-to-face interactions, necessitated new techniques of providing services and maintaining records about individuals.

Thus the rise of giant bureaucracies in government and business represent technological solutions to the managerial problems of a mass society, including also its schools (Clifford, 1987). Early in this century American schools began attempting to rationalize and make more efficient the delivery of curriculum to individual students through building an educational hierarchy, analyzing curriculum scientifically, and turning over the creation of curriculum materials to corporations and outside experts (Budin, in press).

At the same time, educators began to see the possibilities of using organizational techniques to "individualize" instruction and replace the standard recitations of the day (Kennedy, 1902). The phrase "individualizing instruction" has come to have two meanings. In Dewey's (and others') terms, each person is a unique individual whose strengths and weaknesses, interests and needs should be taken into account and provided for (Dewey, 1913). To Dewey the individual is the basis of society, but his or her character is formed through associations and interactions with others (Dewey, 1966/1916). The other meaning of individualizing instruction has been embodied in techniques of delivering instruction to masses of individuals, without regard for the connections between them. The technologies of bureaucracy, textbook creation and devivery, film, radio, and television were key ingredients in this kind of delivery of instruction earlier in the century (Cuban, 1986). In the 1950s educators began to see the possibilities of newer, interactional technologies—the teaching machines of that decade have led directly to modern computer assisted instruction and management systems in which the progress of individuals is recorded and charted. These uses of educational technology parallel efforts in all of society's institutions to replace face-to-face interactions with technologically mediated communication.

Thus the major thrust of technological development and thinking in the modern era has been to assist in mechanizing aspects of the world. Fostered by the foundational belief that humans are naturally in conflict with one another, the effects of technological thinking have been seen in the growth of bureaucracies and systems that "individualize" delivery of services, including instruction. Characterized by a trend toward larger and more centralized systems of delivery, technology has increasingly convinced ordinary people that they are unable to understand its working, and that decisions concerning the operations of most parts of our society should be left to experts. An important implication has been the view of people as passive consumers of products (and information) rather than active producers (Fox and Lears, 1983). Schooling has felt the influence of technological thought in its growing hierarchies of control, its standardization of curriculum and adoption of programmatic learning, and now in the growing popularity of computer technology to deliver instruction.

New linkages of people and technologies

But a set of trends that point in the opposite direction has also emerged, brought about partly by developments in technology. Their potential is to foster connections between people and increase meaningful local decision making and active and productive participation in education.

Communication. The growth of railroads and the telegraph in the 19th century heralded our modern era of a world in which transportation and communication technologies link all parts of the world. Just as the Age of Exploration expanded our horizons and knowledge of other parts of the world, modern technologies such as television and telecommunications are making it possible to know more about, and communicate more regularly with, people around the world. One effect has been the increased realization of global interdependence, implying the need to know and understand other people and cultures.

Media and distributed technologies. Another major trend has been the linking of formerly separate electronic media—primarily audio, video, and computer technologies—to make possible new applications. Multimedia products with which people can access music, video, and voice, as well as textual information, are one result. Equally significant, microcomputer users can increasingly produce their own products—musical compositions, professional looking newsletters, and hypermedia programs using homemade video, to name a few. An effect of this has been to demonstrate that the potential of technology lies beyond the collection, presentation, and management of data; it also enables people to create and to communicate. A corollary effect has been to decentralize and distribute computer power—whereas until recently the major thrust of technological development resulted in increasing centralization of information in large computer systems, the applications mentioned above are now installed in relatively inexpensive standalone workstations.

More information. A third feature of the modern world, related to the two points above, is the increasing amount of information available. The complexity of modern governmental and private organziations is at once cause and effect of the exponential growth in the quantity of data. While more and more of this is accessible to individuals via large databases and telecommunications, quantity and complexity of data require more sophisticated knowledge of how to use it. In work situations, the amount of information necessary for decision making and the complexity of navigating through information systems may now require workers to collaborate in decision making (Zuboff, 1988). Similarly, in schools there may be a growing recognition that complex problem solving necessitates not only that we teach students how to use information but that we allow them to share information and points of view in solving problems.

Thus new ways of looking at the world, aided and abetted by technological developments, may be challenging the dominant trend toward mechanized individualization. The felt need for greater communication and understanding between all parts of the world, the growing complexity of tasks and the information needed to complete them, and the increasing power of convergent technologies that are available in decentralized modes, are but three indications of the possibilities, and even the necessity, of using technology in cooperative and creative ways.

It is important for teachers to realize that technology can facilitate either of these trends—toward greater centralization and mechanization of decision making, and toward a more decentralized and cooperative view of the world. Teachers' own decision making power has been eroded by the former trend. The latter trend is one that can potentially help empower teachers (and consequently their students) to think creatively and critically about their curriculum and how to use technology in it. Just as technology has played a key role in individualism, so its role in fostering collaboration can be equally great.

Implementing Cooperative Learning with Computers

Understanding the general role and potentials of technology as described above is one necessary element of teacher education, but it must be linked to an understanding of what cooperation in learning entails, and what specific computer applications can best actualize the possibilities of cooperation. This section summarizes the main elements of cooperative learning, and then outlines a set of six computer applications in which these can be put to work.

Elements of Cooperative Learning

Cooperative learning is a way of structuring student interaction to further learning goals (Johnson, Johnson, Holubec, and Roy, 1984). Although there are several models of cooperative learning groups currently in use, a set of common principles unites them.

1. Cooperation implies *positive interdependence* between students (Deutsch, 1949). A group is said to be interdependent in terms of its *goals* if all members are working toward a common end. *Reward* interdependence involves a common payoff for completing the activity. And *task* interdependence focuses on how the separate tasks of individual members are interrelated. Interdependence need not be positive. In competitive situations individuals have negative goal interdependence, since each is working for a different outcome. In completely individualistic situations students may have neither positive nor negative interdendence, since what one does may have no impact on goals, rewards, or tasks of another. Cooperative learning situations are structured so that students depend on each other to get tasks accomplished.
2. In cooperative situations teachers must be aware of, and teach students to use, a set of *social skills* that facilitate group work. These may range from simple listening habits to skills of conflict resolution. To make cooperative learning work teachers need to discuss and preteach social skills and continue working on them throughout activities.
3. Cooperative learning usually involves *task and role differentiation* within groups. Students or the teacher may assign individuals separate tasks that later combine to complete the group assignment. For example, in researching a topic students may divide up the content to be researched. In producing a newspaper, one student may concentrate on artwork while another is responsible for layout. In group discussions, roles such as recorder and observer may be assigned. These tasks and roles may also be rotated within groups, so that students have the opportunity to experience several.
4. Cooperative groups are usually *heterogeneous* in ability, giving members the opportunity to learn from and to teach one another, to appreciate the points of view of different individuals, and to share in responsibility for learning with all students.

The task for teachers in implementing cooperative learning is clearly different from, and in some ways more complex than, that of lecturing to a class. To ensure success in cooperative learning teachers: preteach social skills; plan cooperative groupings; introduce topics and tasks and discuss how groups will implement them; observe and intervene in group work; help students "process" their work (discuss the process) to improve future group work; and plan for individual as well as group accountability for task completion.

Within this common framework, there is a range of models for implementing cooperative learning. At one end of the spectrum are varieties of peer tutoring, in which teachers generally define a task and assign group members specific roles in helping one another learn some educational content. Several techniques using structured games or tournaments have been devised to enliven this type of learning. At the other end of the spectrum are techniques of group investigation, in which much more initiative is left to groups in deciding exactly what will be investigated and how it will be done (Sharan and Sharan, 1989/90). These techniques are alike in that students' learning is structured in the ways listed above, but they differ in their conception of the degree of student initiative and the role of the teacher facilitating group work.

A Set of Computer Models for Collaborative Work

Most uses of computers for cooperation today seem to involve either word processing or programming, two applications that have been popular since the advent of microcomputing. In the New York study cited earlier, almost all teachers paired students for joint writing activities, but since almost none of the teachers were informed about cooperative learning techniques, their technique consisted generally of simply instructing students to write together (OREA, 1990). These teachers, typically acting on their own, were constrained by a lack of knowledge about the process of cooperative learning and about a range of computer applications that lend themselves to cooperative work. A summary of six possibilities follows:

1. *Team publication.* Desktop publishing software makes the power of publishing available to anyone with a microcomputer and a printer. Similar to word processing, it adds elements of layout and formatting, plus the possibility of adding a variety of graphics. The variety and complexity of tasks calls for division of labor. Article researching, writing and editing, addition of design and graphics, and layout — each job can be done by individuals or pairs, and the results reviewed by the team.
2. *Decision making with simulations.* Many simulations, particularly those made by Tom Snyder Productions, are designed to foster group discussion and consensus building around important issues. The software serves to organize and manage parts of the activity, while the teacher facilitates group formation and functioning and also supplies information groups need to help make decisions.
3. *Group investigation with databases.* Databases organize, sort, and select information, but their utility rests on the decisions people make about what information to put in and how to use it. Navigating through and manipulating information in a database often requires discussion that takes advantage of several points of view. Student teams investigating problems with databases divide up tasks according to the content to be investigated or database functions—inputting data, formatting it, preparing reports. The most important decisions, however, about what the data means and what its limitations are, often need entire group consensus. Hypermedia, using video and audio in addition to computer text and graphics with software such as Hypercard, represents another kind of database that requires complex decisions about content, structure, and organization of presentation.
4. *Collaborative cartooning.* Of the several kinds of production tools now available on microcomputers (e.g., desktop publishing, music composition, graphics) cartoon creation programs are among the newest. Background scenes, music, a variety of characters with predesigned actions, speech balloons, all combine to let children create movies with up to thousands of frames. We have tried such programs in projects where children as young as seven plan complex cartoons divided into several scenes, dividing up details of conception and implementation.
5. *Collaborative programming.* Programming is potentially one of the most promising vehicles for collaborative problem solving. Not only debugging, but the planning and revision of program structure call for input from more than one student. The realtime, interactive nature of programming on a microcomputer ideally lets students test new decisions and see the results immediately, providing an opportunity for interaction and discussion among team members on modifying programs.
6. *Long-distance collaboration.* A different kind of cooperation is beginning to blossom in the many long-distance projects facilitated by telecommunications. Although in many cases students simply write back and forth to one another, even in these cases they often get to know more about students from other regions or parts of the world. Beyond penpals, other projects have students collaborate in other ways, such as in the collection and sharing of scientific data. One current project at Teachers College has classes around the country collecting data about their own communities which is then input into databases so that each class can compare the nationwide data.

These applications vary in several ways. In some cases the computer allows a degree of complexity and sophistication not possible without it, as in cartooning and desktop publication. These offer students new possibilities while at the same time adding levels of detail to the task involved. Similarly, databases provide opportunities of doing more with information while at the same time demanding a deeper degree of thinking about how to do this. Simulations can help teachers manage complex situations. In all these cases the computer handles many of the technical complexities, leaving students free to concentrate on the essentials of the task and teachers free to focus on how students learn.

For most teachers, however, applications like hypermedia, simulations, cartooning programs, and telecommunications are not part of their usual "training" or else they are covered in a quick and cursory way that leaves teachers inexpert with the software itself and neglects consideration of how to use it. Such applications are manifestly different from individually used drill programs, and therefore require not only learning about applications but, equally important, learning by using them, first with their colleagues and then with students.

In sum, teachers need to know about computers and cooperation in several ways, some theoretical and some practical, and ideally each kind of knowledge should inform the other. The importance of cooperative activity in our world, added to the growing capabilities of technology that can be harnessed for collaboration, make it imperative that teacher education include a background knowledge of the place and potentials of technology, a thorough grounding in principles of cooperative learning, and the opportunity to become expert in applications that best lend themselves to cooperative use. Teacher education that accomplishes such an ideal will equip teachers with powerful tools for educating students in the modern world.

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Using Simucomm: Computer Technology in Teacher Education

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In a typical teacher education program students learn to use traditional sources of information such as books, journals, and magazines. They also learn to use traditional tools for locating information such as library card catalogs and printed abstract and indexing services such as the *Current Index to Journals in Education*. New teachers thus graduate with traditional information acquisition and management skills they can also teach to their own students. K-12 students have access to the same types of information the teacher education student uses - books, journals, magazines - as well as abstract and indexing services such as *Current Contents*. However, the resources of a typical school library may not be able to meet the information needs of students today. A viable alternative to the limited resources of the average school library is an on-line database research. A variety of databases are available today for virtually every area of study. Many are easy for high school and middle grades students to use.

Learning to conduct an electronic search for relevant information is becoming as important as, if not more important than, learning to conduct traditional searches. However, there is the problem of the expense entailed in any database search (some as high as $8.00 per minute). Additionally, people must be trained in telecommunication techniques and few school systems are able to provide the funds for purchase of hardware, much less pay the cost of a dedicated telephone line for training purposes. How then does the teacher who does not have telecommunications facilities (or computers with CD-ROM drives and CD-ROM information discs) economically teach students to use electronic information services? And how do teacher education programs with similar constraints instruct future teachers to use electronic information services? Teacher education institutions have had some success in using a public domain computer program entitled Simucomm in preparing teachers to use telecommunication techniques in their own classrooms. The part of Simucomm that will be described in this paper is Infosource.

Simucomm simulates using a microcomputer to access a remote, host computer via telephone lines. Using this simulation, students of teachers who have access to only one microcomputer (and no communications hardware, software or telephone access) can engage in the process of communicating via a computer-to-computer link. In addition, students can access a teacher-generated database in order to retrieve information.

Using Simucomm in Teacher Education

This paper describes the integration of a public domain simulation, Simucomm, into an undergraduate teacher education course. The class syllabus describes the simulation and explains why it will be used in the class.

The steps for using Simucomm are as follows:

Step One: As indicated in the syllabus each student will be prepared for on-line simulation experience through having read at least 3 articles relative to the use of on-line search techniques in a secondary classroom.

Step Two: After students have read about on-line searching, the instructor introduces the simulation and explains why teachers should know how to conduct on-line searches.

Step Three: In Step Three students actually play the simulation. Simucomm lets the student work through the steps in conducting an on-line database search without the attendant expenses. It is a four function public domain program developed by Dr. Jack Gittinger at the University of New Mexico. For the purposes of this class, a science education course for pre-service teachers, we use only the fourth part of the program (Infosource) and we insert actual responses from a Dialog database. Simucomm is used in a laboratory situation with each student having his or her microcomputer (Apple IIe series). Each person is provided a preprogrammed Simucomm disk and a problem to work through (e.g., locate information on a particular topic). Computer literate students have no difficulty using Simucomm to accomplish their assignment. Students with little previous computer experience must be given some assistance.

Because it is a public domain program, they will also be able to use it in their own classrooms when they graduate. And because the "database" in Simucomm that students search can be customized by the teacher, it can be adapted to almost any type of course.

Step Four: After they have completed the simulation, the students are given a short list of questions that can be answered with the information embedded in the database installed in Simucomm.

Step Five: The final step is a discussion of the ways electronic information searches, and the simulation, can be used in other settings. Students are asked, for example, how they would use Simucomm with their own students.

Discussion

Simucomm has been an excellent addition to our undergraduate methods course. In situations where the "real thing" is not possible, Simucomm provides students with a realistic experience. In fact, Simucomm may actually be preferred to the real thing in some situations because you can select and customize the content in the simulated database to fit your own goals and objectives, and there is less likelihood of problems because of telephone line problems or a mainframe computer at the information service that is down. In our classes students are allowed to keep the disk and are encouraged to use it in their classroom. We use Simucomm with science students but it could be used in many other methods courses as well, courses such as social studies, language arts, reading, math, music, art, or foreign languages.

References

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