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ABSTRACT

This collection of 23 essays on the applications of technology in education, commissioned by the U.S. Department of Education, is divided into four chapters. The first chapter examines the effect of media on the message to be delivered, and includes essays on classroom use of television, the use of computers to support the learner, and telecommunications in the classroom. The second chapter examines the effect of media on learning, and includes papers on computer instruction and thinking skills, computer development for equity in computer education, and online computer databases in school library media centers for developing skills in information use and critical thinking. Chapter three examines the use of technology to support the disciplines, including science, humanities, reading, and writing instruction. The final chapter focuses on the organizational requirements in schools that choose to use technology, and includes essays on technology introduction, copyright law, and evaluation of a school's technology program. Each chapter begins with a synthesis of the essays included. Most essays contain references and some contain recommended readings. (GL)

TO SUPPORT THE LEARNER:

A COLLECTION OF ESSAYS ON THE APPLICATIONS OF TECHNOLOGY IN EDUCATION

Enhancing Learning Through Technology

Office of Educational Research and Improvement
United States Department of Education
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Program Officer
Frank B. Withrow, Ph.D.
Team Leader
Technology Applications Group

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ACKNOWLEDGMENTS

These articles were commissioned by the Recognition Division of the United States Department of Education to provide information about the use of technology in education and library programs. It is our hope to increase communication among librarians, technologist, and elementary and secondary educators about the importance and use of educational technology. This document was conceived by Jean Narayanan, Team Leader for Identifying and Recognizing Excellence in the Recognition Division and Dr. Frank B. Withrow, Team Leader of the Technology Applicatiuons Group in the Research Applications Division. Their intent was to communicate current information from innovative, Federally funded projects to curriculum planners and decision-makers at local and state education agencies.

The outline of **To Support the Learner** emerged during a day-long meeting in Washington, D.C. In addition to Jean Narayanan and Frank Withrow, those who gave their time and ideas to that session were Charles Blaschke, President of Turnkey, Inc., Marvin Koontz, Director of Instructional Technology for the Fairfax County Public Schools; Ann Erdman, Project Officer, U. S. Department of Education; Dr. Regan McCarthy, Director of the MASTTE Project, at Bank Street College of Education; Andee Rubin, Senior Scientist at BBN Laboratories, Inc; Jean Saunders, Senior Associate Director of the Merrimack Education Center; and Benjamin Thomas of Sidwell Friends School. Ronald Cartwright served as the project officer for this effort.

To Support the Learner would not have come to fruition without the enthusiastic participation of the authors. Each freely gave time from full schedules to create the product that follows.

Editorial support was provided by Bruce O. Boston of Wordsmith, Inc. Dawn Miller cheerfully and efficiently entered and then made modifications to all articles on the word processor.

To Support the Learner provides curriculum decision makers at the state and local level with case studies of current or recently completed education projects that use one or more electronic technologies. We hope the format we have used will communicate their experiences clearly and with enough detail to enable readers to use the information while it is current.

To Support the Learner is not a recipe for using technology, but a series of sign-posts. Its contributors continue the debate between advocates of increasing uses of technology for enhancing traditional education and those who favor using technology as an expansion tool for critical thinking processes. However, it is evident that these and other questions about the nature and impact of electronic technologies must be pursued with specific learning goals in mind. What we should use and how it should be used can best be answered not by addressing the technology itself, but by adopting the perspective of the learner, with clearly conceived educational objectives in mind. These technologies help us confront these critical questions from a fresh perspective. Once we understand the benefits and limitations of technology we may find that they expand the options for education.

Ultimately, the decision about when and where to use technology is a local education decision that must meet the needs of the local community served by the schools.

The gathering together of these essays was part of a grant to RMC Research Corporation, 400 Lafayette Road, Hampton, N.H. 03842. Andrew J. Seager was the Project Director for this effort.

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TO SUPPORT THE LEARNER:

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Program Officer
Frank B. Withrow, Ph.D.
Team Leader
Technology Applications Group

Programs for the Improvement of Education

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SYNTHESIS:

TECHNOLOGIES AS MEDIA FOR LEARNING

by Laura M.W. Martin

If we had written this series of papers fifty years ago, we might be featuring the importance of electric lighting in classrooms and the need to assure that all children who needed glasses were fitted with them. Those two technologies enabled many to be lifetime learners. In 1938 we would have been concerned with the fact that only 35 percent of our children completed high school. If we had written this book in 1948, we would have been concerned with how to handle the post-World War II needs of an expanding technological society; in 1958 we would have been concerned with Sputnik and what it meant for world competition in science, mathematics, and foreign languages and how teaching machines might bridge the gaps. In 1968 we would have been concerned with technology as a way to bring equity into our schools. In 1978, we would have concentrated on how to use technology to mainstream handicapped children. In 1988 many of these same questions are still viable, but the difference is that we have resources that can make applications of technology user-friendly for both teachers and students. In 1988 75 percent of our children graduate from high school, but we are now concerned with quality. We are concerned, too, with the "at risk" populations and how to bring the last 25 percent of these children into the educational community.

Too often in the past, technology has promised too much and delivered too little. Today, however, advances in interactive technology and State initiatives have changed the picture for applications of new and old technologies to learning (see Crumb, pp. 17-25). First, as the "tool functions" of microcomputers (e.g., word processing, spreadsheets, databases, art utilities, computer assisted design, and music synthesizers) became more evident, the problems of implementing electronic technology within the curriculum began to be recognized and addressed across a wider front. Second, since there is less emphasis now on promoting computer literacy as a separate class, educators are thinking more carefully about how media change the learning process. This shift has resulted in a reexamination of the cognitive effects of some of the old technologies, such as television, radio, and print (see e.g.

Greenfield, 1984; Brown, 1986), and has begun to suggest real advantages to using electronic media for learning (also see Schwartz, pp. 119 -124).

ANALYZING EFFECTS OF LEARNING

Although formal studies of computer-based learning gains are still in their infancy, some specific advantages to using these devices have been measured. For example, in his article Glenn Crumb reports cost-efficient gains in mathematics achievement among adult and child students using drill-and-practice software. Teachers and students have reported increased motivation, time-on-task, and comprehension in science activities as a result of using an integrated media package (see McCarthy) or video alone (see Mielke). Increased mastery of complex interpretive skills has been observed in the case of computer-based writing programs (Pea & Kurland, in press), in mathematics, and in other curricular domains described in this volume.

Apart from their effects on traditional school skills, computers, video, and videodiscs are being viewed as new <u>mediators</u> of learning. Far from being mere extensions of books or of other familiar classroom tools such as filmstrips, these technologies have been seen to catalyze, shape, or even determine lesson content and format in unique ways. Sometimes, entirely new thinking processes seem to emerge (Pea, 1985), although not always in ways that developers envisioned. Withrow describes, for example, how the masses of visual, textual, and aural information available from computerized databases can be sorted and accessed in qualitatively different ways using interactive, compact-disc technology.

In fact, as several authors here note, we are witnessing a developmental process in which designers create a program or programs they think are useful; teachers then try them out, run into problems (or not) and create new uses for the materials. The designers in turn modify the programs to reflect the realities of use, often thereby changing the teacher's role in the learning process, and sometimes the curriculum itself. It should be noted that in no case has the teacher been replaced as a result. In fact, the importance of the teacher in the process is recognized as central (see Withrow, pp. 34-40).

THE IMPORTANCE OF CONTEXT

Analyzing the effects of a technology as a mediator of learning doesn't necessarily mean a study of its effects on individual learners alone. As we see in the essays that follow, educators, researchers, and designers have come to understand how media can be applied to learning and teaching. What results is a new consideration of the social implications of technology and the resulting changes in teachers' and learners' interactions.

A key factor in the context of learning is in what Glen Crumb calls "the critical role of the teacher in interpreting how new technology can be used for productive teaching and learning," which he says may "shape the successes that the new technology will have." Even with computer-assisted drill and practice programs, the teacher's role can affect outcome.

The teacher, too, is a mediator, as Keith Mielke writes. Teaching moreover, is carried out in different contexts, whether by the parent (or even other children) in the home or by the teacher in school. Variations in the setting can change the the technology's capability for enhancing instruction. It is necessary, therefore to take into account the learning environment, access to the technology, teacher/student ratio, technology/student ratio, and the goals of the activity--when designing and assessing the learning experiences mediated by technology or before determining their overall effectiveness.

Considerations such as the expense of the technology, the educational agenda of a school district, even the decision-making structure of a district, will all affect how a single device may be used by an individual teacher (Martin, in press). For instance, scheduling adequate time with equipment can be a major problem in some schools, requiring an understanding and supportive administration. Dennis Newman, discussing the implementation of telecommunication projects in schools, reminds us of other ways that the technology and classroom realities intersect to affect user control. He finds that the technicalities of introducing an electronic bulletin board into a school demand an initially high level of system operator advocacy, which may mean organizing release time for the operator.

Each tool and player in the learning situation comes with a particular history of enthusiasm for or familiarity with technology which must be taken into account by designers and consumers alike. From what Mielke and McCarthy say, we may expect that using video as an education tool in school may have distinct advantages because children are comfortable with this technology from home useage.

CONSIDERING WHAT MEDIA DO BEST

Within a given context, good technology-based activities take advantage of what a medium does best (Mielke). For example, using computer networking for accessing large amounts of up-to-the-minute data (see Newman, pp.26-33), videodiscs for providing customized, multilevel information searches (see Withrow, pp. 34-40), and microcomputers for economic delivery and analysis of skill practice programs (see Crumb, pp. 17-25). They can also be combined to accomplish several purposes (see McCarthy, pp. 41-52). Used judiciously, media can result in a variety of rich learning experiences.

No single medium covers all of our educational needs. All technology can and should be integrated as regular curricular resources. Multimedia resources offer the opportunity for natural integrated thinking about a given subject which can motivate and teach students. It offers the potential for more in depth understanding of the knowledge and skills needed by the learner.

CONTROL OF THE MEDIA AND THE LEARNER

As educational technology becomes more sophisticated, both teachers and learners are offered greater control of the content. Technology means more local control and more teacher control of sophisticated curricular resources that can meet the specific needs of a given community and even the needs of the individual student. Withrow (pp. 34-40) describes how technology can free the teacher and student to increase their communication skills and stimulate self-motivated learning.

The authors of these essays stress that if we are to make the fullest use of the promises of technology we must (a) consider the larger environment in which a particular technology is used, (b) develop realistic expectations of the media by considering what they do best in given circumstances, and (c) review and revise, as the technology designers do, the goals and products of our efforts. The authors encourage experimentation under conditions that provide ample support in the form of training, equipment, access, and resource-sharing. Although the results of formal studies of various media sometimes surprise us, positively and negatively, the contributors are convinced of the transforming capabilities of technology for the professional benefit of the teacher and the educational well-being of the student.

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Laura M. W. Martin, Ph.D., is a Senior Researcher at the Bank Street College Center for Children and Technology. She coordinates research for Mathematics, Science and Technology Teacher Education Project.

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CLASSROOM USE OF TELEVISION
by Keith W. Mielke

INTRODUCTION

Although the Childrens Television Workshop's (CTW) four major educational series for children --SESAME STREET, THE ELECTRIC COMPANY, 3-2-1 CONTACT and SQUARE ONE TV -- have been designed primarily for home use and only secondarily for use in schools, we at CTW consider ourselves close allies to teachers and schools. We seek the advice of teachers when we design, produce, and evaluate programs; we provide various support services to schools. For fifteen years our series have been used in elementary classrooms across the nation. CTW does not primarily see its programs as restricted to schools. If we were to draw a picture of our perceived role, it would be a Venn diagram, with overlapping circles representing our simultaneous commitment to the growth and development of children, education, and media. Marching to these three drummers has taken us first into the homes and then into the schools. We try to use both environments fully, since we believe one reenforces the other in best of all worlds.

TV AS AN EDUCATIONAL MEDIUM FOR THE HOME AUDIENCE

Because of the inherent qualities in the medium itself television can be a serious educational tool. Television is not a novelty or an "experimental" technology; it is a sophisticated and heavily used delivery system for all kinds of messages that can be found in virtually every American household. Young children are heavy watchers of television . Their use of television makes children video experts: They rapidly absorb, organize, and internalize enormous amounts of information through this medium; they understand its conventions and formats. A substantial amount of what children know about the world is learned from television. Thus, television is an inescapable fact of children's lives: not everyone professes to like it, but few would deny its penetration and power. The challenge is to go beyond the superficial judgements, especially for those who feel that television is a part of a grand cultural problem, or for those who yearn to return to a so called simpler life of yesteryear.

While it would be a mistake to underestimate the power of television, it would also be an error to consider it omnipotent or independent of a child's total environment. Television is neither a panacea nor a scapegoat for educational problems. It can be a powerful instrument in our educational armory, to be used intelligently alongside textbooks, books, telephones, and computers by learners and teachers. Television can do some things better than other resources, and good educational management includes harnessing the particular strengths of each rescurce. **Good** uses of television include:

o telling stories,

o showing and demonstrating things that otherwise could not be seen at home or in school,

o going places that would not otherwise be visited,

o providing living role models,

o illustrating concepts in visual metaphor,

o capturing phenomena in their human and emotional contexts, and

o promoting compelling graphics that model and facilitate thought processes.

The design and production values for educational television need not--indeed should not--be clones of classroom practices; but rather should be sensitive to what this particular medium can do well. For example, true interactivity is not possible in broadcast television, but high levels of viewer involvement and participation are possible. So called "hands-on" activities are not a particular strength of television, but "eyes on" is a very powerful educational strategy that is regularly used by the best in educational television.

Cost effectiveness is just as important as pedagogical effectiveness, and there is a compelling and overwhelming economic argument that favors using television in the home. The television signal is a great equalizer, reaching the rich and poor alike with identical programming that can be understood by good readers, beginning readers, poor readers, and nonreaders in a nonpunitive setting. Whereas the classroom is a local and state affair, television can be programmed nationally, regionally or locally, but in any case, the economic advantage is through the delivery of the television signal. By reaching audiences in the thousands and millions, the cost per program exposure is less than a penny per child. Furthermore television is different from many other educational supplements such as newspapers, theater performances, and field trips; because adding one or a million more children adds nothing to the cost of a television series.

Recognizing the enormous opportunties for the use of television for learning, CTW launched SESAME STREET in 1969 with the funding support of the U. S. Office of Education. This experiment envisioned the use of a system that was already in place in the homes of all socio-economic levels. Through a voluntary home audience, millions of children would watch, enjoy, and learn. This bold experiment required the developers to play by the rules of the existing system, which were that the audience could with extreme ease--a push of a button, a turn of the dial--tune out and switch to another activity. They never risk being censured for violating rules of etiquette. The home environment has demands and opportunties; it has a sociology that must be taken into account. The home audience must be attracted and sustained as well as taught: Appeal and comprehension are not side benefits, but basic prerequisites. Although it's not easy to score equally well on both fronts, education and entertainment are not antithetical: They are not two parts in a zero-s game. One of educational televisions most important and most overlooked achievements has been to provide the occasion for a new kind of educational teaming in which the content experts, television producers, teachers, and educational researchers have been brought together in new and more fruitful combinations.

THE SCHOOL ENVIRONMENT FOR EDUCATIONAL TELEVISION

As an educational show for preschool children, SESAME STREET, was not intended for school use. [Even so, an estimated 34,400 teachers were using it in their classrooms according to 1982-83 Corporation for Public Broadcasting survey (CPB, 1985).] The first CTW effort directed towards both the home and school was THE ELECTRIC COMPANY which premiered in 1971. It focused on reading skills for children seven to ten years old. This home and school approach continued with the introduction of 3-2-1 CONTACT in 1980, a science awareness program for children eight to twelve years of age. This dual focus was added to in 1987 with SQUARE ONE TV, a mathematics program designed for the eight to twelve year old.

Research has shown us that these series also attract a younger audience as well as the intended one. 3-2-1 CONTACT and SQUARE ONE TV set a stage of readiness for these younger children. It should be pointed out that all CTW programs carry the closed caption for the hearing impaired child.

Because the school setting changes almost every environmental factor for viewing television, programming for the schools must be understood on its own terms. Differences between the home and classroom are:

o The home audience most often contains viewers of different ages, whereas classroom viewers are age peers. Thus developmental stages, level of experience, social roles, and peer acceptance are all factors in the classroom.

o The home audience drifts in and out at leisure with no negative social consequences, whereas the classroom audience is captive. In the classroom formal and informal roles guide and sometimes override an individual's inclination of the moment. (A more subtle but no less powerful point is that one cannot force attention upon even a captive audience; people may be required to stay put, but they simply tune out.)

o At home, people usually view in small groups or alone, whereas in the classroom it is usually a large group activity.

o The motivations to watch television at home are enjoyment, diversion, and relaxation, but the classroom motivation, as mediated by the teacher, is to meet a learning goal.

o The home viewing experience is for the most part self-contained, whereas in the classroom , again mediated by the teacher, it is a part of the larger instructional plan.

o Home viewing is at random or dependent upon the will of the viewer, whereas the classroom viewing is controlled and specific.

o The appeal of a show to a home audience must rely on what the child can perceive moment by moment. The same show retains the basic appeal and content put there by the producer, but in addition the teacher can exert enormous influence by pointing out things of special interest and importance. The teacher may interpret and reinforce the original goals of the show or go off in another direction entirely. Adult co-viewers in the home can do this as well.

The pedagogical advantage obviously belongs to the school. If a show works educationaly at home, with no adult intervention, then it will work even better in school with the mediation of a good teacher.

A CPB Department of Education survey (1985) indicates that almost all US classrooms have access to television and that 70 percent of our teachers use some television. Additional information indicates that teachers trained in using technology are more likely to use television on a regular basis, with 37 percent of all teachers using television on a regular basis. Obviously, use varies with class content and available programs, as well as with teacher skill in integrating programs into the regular curricular.

While almost all teachers have access to television in their classrooms, viewing is not achieved with the ease of home use. Schools have policies, breaucracies, redtape, and set up requirements that act as barriers to television use. Tressel reported that broadcast schedules limited the use of programs, wheras flexible use of the same recorded program increased use. Use and barrier data have remained essentially constant over the last decade. However, the more universal availability of VCRs in schools may change this pattern.

Recently, teachers have been explaining these barriers to us in terms of teacher control, reward/effort ratios, and priorities. Teachers, reasonably enough, prefer not to feel "paced" by the external broadcast schedule. If, in addition, the mechanical aspects of using televsion are stressful and inconvenient, then at some point using educational television becomes not worth the effort. Some teachers point to the pressures of the reform movement with essential elements and standardized tests that leave little room for anything other than the prescribed curriculum. In short, the teaching time allocated in most United States schools is very tight, only about 900 hours per year. Introducing any new element requires a shifting of priorities. Therefore, any new resource must demonstrate its relevance to the expected curriculum.

All studies of the use of television in the classroom indicate that when teachers have been trained to understand effective uses of television the results are better and the teachers and students achieve higher levels. It is essential that teachers learn how to teach effectively with television. That does not mean that all programs must we viewed in school. As a matter of fact, THE ELECTRIC COMPANY, 3-2-1 CONTACT, and SQUARE ONE TV may be more effectively used when viewed outside class time and reinforced in class time.

CTW EXPERIENCES IN SCHOOL TELEVISION

THE ELECTRIC COMPANY (TEC) developed decoding and coding reading skills, obviously a top priority in early elementary curriculum areas. It transformed drill and practice into an experience that was entertaining and fun as well as soundly based in principles of reading research. TEC's success was impressive both in the speed with which it was adopted and in the number of teachers who used it. Within two months of its premiere, TEC was being used in 23 percent of U. S. elementary schools: among schools fully equipped for classroom television, the figure was 45 percent (Herriott & Liebert, 1972; Liebert, 1973). In addition, two CPB surveys, six years apart, found that TEC was the most widely used classroom series in the country even though it had been developed primarily for a home audience (CPB, 1979; 1985). A number of research studies have examined a wide range of uses of TEC in the schools. Some just "let it play" while other included extensive teacher interventions. Mielke (1977) and Palmer (1978) have reported extensively on these projects. Educational effectiveness was evaluated two years in a row by the Educational Testing Service which found that viewers achieved significantly more than nonviewers in 17 of 19 sub-goals (Ball & Bogatz, 1973; Ball 1974).

Within elementary schools, science is accorded quite a different status from reading. Less time is allocated to science and elementary teachers report that they feel least comfortable in teaching science (Weiss, 1978). Moreover, elementary teachers for the most part are required to teach all subjects in a self-contained classroom. To meet the need in this area CTW introduced 3-2-1 CONTACT in 1980. Unlike TEC, which was an integral part of the regular curriculum, the goals and objectives of 3-2-1 CONTACT were not a part of many elementray school curricula. For 3-2-1 CONTACT teachers require more precision and advanced planning to be able to match program content to lesson plans (Storey and Mielke, 1981).

We want to know how and to what extent 3-2-1 CONTACT will be used in classes under conditions where teachers

o are fully informed about the scope and utility of the series;

o are professionally trained in the classroom use of the series;

o have easy access to complete segment descriptions, all cross-indexed with leading textbooks; and

o have easy access to television and VCR's in their classrooms with a complete set of the series tapes.

CTW is already working with SQUARE ONE TV to make it a useful classroom resource. Since this program deals with mathematics it is more likely to be an integral part of the regular curriculum of the elementary school. However, just like the science program, teachers are not comfortable teaching true mathematics. Tailoring nationally available materials to individual needs cannot be done in the studio; it must be done at the point of consumption. This strongly suggests a strategy suggested by our research on 3-2-1 CONTACT. To be most effective, resources need to be teacher/student-controlled where television materials are not just available, but are truely accessible tools for both the learner and teacher to use when they are needed.

THE FUTURE

Predicting the Future Is A Hazardous Exercise At Best.
Some Trends Are Already Visible: Others Can Only Be Guessed At.

o Low-cost VCRs are already making their way into many schools and classrooms across the nation. They are already available in more than a majority of our homes. This is a significant shift in accessability for both the teacher and student. Playback units in bulk purchases are around $100 and the cost of tape and duplication is minimal. Videodiscs offer even greater flexiblity and access.

o The interdisciplinary use of materials is an educational trend that enables a science show to be used in language arts, art, or mathematics.

o School libraries can and are developing videotape libraries that students can use in the home. A whole new resource is available to teachers to enhance learning with such libraries.

o As we develop new teacher support services, CTW programs can become an integral part of extracurricular or out-of-regular-school use. Electronic bulletin boards and data bases can be used by teachers and students to increase the value of these programs.

In summary, education is not a single operation, and television is not a simple medium. The role of television in formal education must be considered by educators in the context of the total learning environment, i.e., in the classroom, community, and home. In such a setting teachers will do what they do best and will employ televison to do what it does best. In such an environment, television's contribution to excellence in education will be enormous.

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USING COMPUTERS TO SUPPORT THE LEARNER

by Glenn H. Crumb

Educators, parents, and the public are asking penetrating questions about the relation between computers and educational goals. Practioners have become informed consumers who demand reliable, valid courseware that is error free and "user friendly." This sophistication also leads them to seek courseware that make appropriate use of sound learning principles, productive teaching methods, and accurate content. In school, the power of the computer is being used to provide support for content instruction, management for learning, and documentation of both time-on-task and learner achievement. Finally, .d perhaps most significant, the computer's use has been expanded to helping the teacher apply diagnostic-prescriptive teaching practices that use the time of both teacher and learner more efficiently and effectively. The computer is giving the educator a tool to increase educational effectiveness and provide accountability..

HARDWARE DESIGN AND USE

Two types of computers have found their way into our lives: One is a large mainframe or mini-computer with terminals; the other is a personal computer. General-purpose, personal computers (PCs) can be used in a variety of contexts, from word processing to financial management to educational programming. These machines can be broadly used. Other machines have much more computing power, but are designed for single purpose activities, e.g. computer-assisted design (CAD), computer-assisted instruction (CAI), and/or computer-managed instruction(CMI). The more powerful systems have a larger educational data base and combine both instruction and management. Cost varies with the purpose and power of the computer system. A school district may decide to purchase or lease a system designed for virtually any educational purposes, or to provide instruction in any subject. Such systems may be more cost effective for schools than more general purpose PC's.

The reason for these two types of machines is a matter of simple economics. The profit in broader-use machines lies in a larger, diversified marketplace; the machines developed for more intensive classroom uses have a narrower range of customers. Educators and school administrators must be aware of the trade-offs with regard to educational objectives. Networking and the blending of the two systems is more a possibility today than in the past. A school system should be very clear about what it expects a computer to do; administrators must make careful decisions to avoid expensive errors and wasted learner time. With further development of computer controlled interactive videodiscs, developers are exploiting the power of systems to store and retrieve visual and audio images as well as text data. Such systems are beginning to find their way into classrooms at all levels, from elementary school to college. The inevitability of such systems being in the home as well as the schools in the 1990s is reinforced by the development of digital television for home use. By the mid-1990s, the digital design of home television sets will enable them to have routine computing capabilities comparable to today's home computers.

EDUCATIONAL GOALS

Without question the future livesof virtually all of today's youth will be entwined with different uses of computers. Schools, therefore, have a clear responsibility to provide opportunties for students to learn about and learn how to use computers. We have come to understand, however, that after the first blush of acquaintance with the computer keyboard, cursor manipulation, a "mouse," and simple structured programming (Logo, BASIC, etc.), instructional uses of computers have been limited. These limitations have been caused primarily by five factors: (1) the early misconception that to use a computer required a person to be a trained programmer, (2) the absence of a sufficient number of teachers of any subject who had training in computer use, (3) the lack of interest among teachers in going through the rigorous training needed to become a programmer, (4) the lack of knowledge and training in learning psychology and of pedagogical methods among trained professional programmers, and (5) the unsupported belief that students who have learned programming would have simultaneously learned problem solving.

Pea, Kurland, and their colleagues (1985) for example, found that programming produced little spontaneous transfer to problem solving; indeed, they found it very rare across a range of school settings, grades, school populations, and measures of transfer. The level of programming that might provide transferable skills proved difficult for many students to reach. Studies of adult and child expert programmers revealed that students needed much more time, more sophisticated hardware, more software, and more programming help than they were likely to get in school programs.

Other computer-based activities, such as cursor manipulation, were initially thought to have potential for increasing sophistication in problem-solving skills. Hawkins (1984) found, however, that students looked at Logo programming largely as an activity for making intriguing and interesting forms on the screen; the means by which they did this were relatively unimportant to them. Thus, they reached their goals without learning and using the powerful tools of elegant programming techniques; the hope that programming would develop thinking and reasoning skills was not realized. As a consequence, teachers have shifted from that global goal toward more specific goals.

Clearly, schools need to define their educational goals sharply before deciding where to use computers. Continued study of computer uses in schools will, no doubt, identify more ways to support the learner. For example, basic skills instruction with drill and practice has already been established as an effective and efficient use of the computers, although access to software and the costs continue to be a concern.

SOFTWARE CONSIDERATIONS

Many schools find the costs of good quality software too high. Although numerous systems for developing one's own software are now available, the fact remains that developing and producing quality software is costly. But, as in the case of hardware purchasing decisions, the real cost lies in selecting poor software. As with any education material, educators are responsible for determining that the software meets content validity and good learning design, and that the product is error free and appropriate for the grade and age level of the user. Huge numbers of programs are available on floppy disks in a wide range of school subject areas. However, studies of effectiveness andvalidity tests of these products are still very limited. When James Kulik and his colleagues at the University of Michigan conducted a meta-analysis of over 300 separate research studies on CAI effectiveness, they eliminated 250 studies because of flaws in research methodology (Bracey 1982). Of the remaining 50, however, they concluded that students receiving CAI instruction scored better on standardized achievement tests than did their peers who received no CAI. They also found that CAI-taught students had better retention and that CAI improved the speed at which students learned a given amount of material.

Two inferences follow from this research. First, learner time-on-task can be more efficient with CAI. Given the rate at which knowledge is increasing, more efficient learning grows in importance as each year passes. Second, educators and researchers should try to identify hardware and software that specifically leverages the power of the computer, not only to provide instruction but also to meet the specific needs of the learner. Finally, as the search for more effective and efficient means of learning continues, perhaps the computer can become an effective tool for data collection to document the information needed to test various instructional models and their costs.

MASTERY ACHIEVEMENT MODELS VERSUS COST

Data collected from projects conducted in a variety of school settings, including California, Kentucky, Louisiana, and Massachusetts, provide evidence of class-average achievement gains of more than 1.0 years for every 25 hours of time-on-task use by students. The CAI materials used in these projects were the Computer Curriculum Corporation's reading and mathematics software, which mainly provides drill and practice. The students in the best-documented models received ten minutes of CAI time-on-task each school day, had teachers who provided individualized concept instruction based on diagnostic-prescriptive information generated by the computer, and were involved in at least one teacher-reported, motivational CAI activity each semester. The hardware to deliver the CAI was either terminals connected to microcomputers or stand-alone microcomputers. In most cases school sites were connected by telephone or microwave systems to a centrally located minicomputer.

The costs of communications, courseware, hardware, and system maintenance appear at first to be beyond the reach of most schools. But given the achievement gains reported, the ability to document student progress at will, and the high efficiency of mastery achievement, the costs may well be less than investing in hardware and courseware on floppy disks that have none of these advantages.

Schools using the centralized systems and programs have discovered other advantages. After school hours they use the CAI network to provide basic skills instruction in adult education programs; during the summer they keep one facility open to provide CAI instruction. Evidence indicates that providing learners with as little as three or four weeks of CAI, using elements of the model cited above, yields close to three-fourths of a year of mastery achievement in basic skills. The Jefferson County Kentucky Schools, for instance, are opening a new school for those still of school age but who are out of school and without a high school diploma. The school will operate primarily at night, use mastery learning strategies, award Carnegie units toward the high school diploma, be entirely individualized, and make heavy use of CAI to provide instructional support. The multiple uses of hardware with more applications not only reduces overall costs for instructional services, it also provides insight into how computers can be used to deliver productive learning activities. Still other benefits of significance are: (1) the ability to administer centrally the analysis and reporting of mastery achievement (2) administrative communication through electronic mail, and (3) meeting the instructional needs of homebound students using dial-up access to the computer. At this time these administrative capabilities are being used only in a limited way, but there are indications that further expansion will occur as more administrators become aware of the power and availability of such resources.

With advances in computer and communications technologies, the ability to tap into substantial amounts of computer power for classroom use at a reasonable cost continues to grow. Cooperative CAI networks are one way of doing so. In Kentucky, a consortium of 24 public schools and a comprehensive university share the administrative, hardware, courseware, maintenance, and communications costs of CAI instruction. The cost per school year for services to 25-30 middle school students is about $900. For this a student has an excellent potential to gain more than one year of achievement in mathematics or reading skills as a result of drill and practice used with a planned program of concept teaching.

In one rural middle school, the average CAI math gains exceeded 2.15 years for 62 Chapter I students, who had an average of 20.23 hours of time on-task. After two years of using the program, this school is reporting no students eligible for Chapter I mathematic with only incoming students needing remediation . The average cost to the school per year of CAI achievement gain was $42.10 per student. At another isolated rural school, 36 students have access to CAI for just ten minutes per day. These students had an average mastery achievement gain of 1.84 years at a cost of $26.42 per student per year.

NETWORKING AND CAI

A variety of networks are available to individuals and organizations. The objectives and benefits of being a participant in one or more networks vary broadly. From economic to personal or professional pleasure. Access is readily available for connecting the owner's computer with the system. A sliding fee for time on the system and the long distance toll charges round out the costs.

The environmental education program of the Jefferson County Kentucky Schools makes use of data collected about teachers in workshops and students in classes and seminars. This data base provides one source of information needed by students to solve problems posed by teachers of the system.

The number of telephone and microwave communication networks to support remote classroom sites has been growing rapidly since the early 1980s. More rapid and reliable modems, improved telephone systems, and the application of new and sophisticated computer communications technology have provided more school systems a cost-effective means to network CAI programs. The development of better and less expensive microwave systems and more efficient use of those already in place have also made their contributions. In south central Kentucky a group of seven school districts share a network that provides CAI in basic skills (reading, mathematics, language arts). The network consists of a state -owned microwave and telephone lines that connect a minicomputer at Western Kentucky University with remote classrooms at distances of up to 100 miles. The CAI is available at some sites for both day and night school applications. Electronic mail is used routinely to communicate among classroom teachers, administrators and university personnel. The network has operated since 1984 and proven to be effective in supporting the learner and teacher.

LOOKING AHEAD

The use of computers in schools will expand as their effectiveness and place in instruction, classroom management, and administration become better understood by educational decision makers. The critical role of the teacher is in interpreting how new technology can be used for productive teaching and learning. There must be a synergistic interlocking of technology as a relevant part of the curriculum if it is to be used effectively. Teachers must be comfortable with the technology, use it to learn themselves, and have the support that allows them to make maximum applications of the technology resources available in specific content areas.

In the 1990s hyper-media will be available in the homes and classrooms of America. This means that the digitally based television in your home will be more powerful than personal computers today. Such systems connected to telecommunications systems from telephone lines to satellites will be able to provide learners and teachers astronomical amounts of text, audio, and visual data. Theoretically, the entire collection of the Library of Congress can be "reached out and touched" through your telephone line. International data bases in the hard sciences are already accessable among universities and can be accessed by high schools students. The newer digital technologies, that in some instances are laser based, allow for the use of information in an infinite variety of formats from text to full motion, color, sound, all under the control of the learner and/or teacher.

Mature systems for education will focus on content and learner mastery of that content. Time will not be the fixed basis for education with mastery flexible for individual students, but mastery criteria standards will be fixed and time will be flexible. Such systems as I have described will include instructional, diagnostic-prescriptive, documentation, management, and testing components. Developmental prototypes of these systems are already being used in business and industry, both for life-long education and for retraining workers.

The essence of educational technology is the appropriate use of human and nonhuman resources to change the learner's behavior so that new skills are developed, new knowledge is acquired, and performance meets an agreed upon level of acceptance.

The tools are available, and the challenge is great; the question is how we in education will adapt to the needs of an information-rich society. The

United States educational system, with its mix of private and public education, enabled us to dominate the economic and industrial world during the last part of the industrial age. The question facing us is whether we can shift to the needs of the information age or whether we will cling to the bones of yesteryear. I think that we will meet this challenge.

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TELECOMMUNICATIONS: A PHONE LINE IN THE CLASSROOM

by Dennis Newman

Just a few years ago, it was unheard of for a telephone line to be in a classroom. Now as computer rooms, libraries, and resource data rooms are installed, telephones have become almost commonplace...not because more teachers are finding time to chat on the phone, but because phone lines are a vital link between the classroom and the world beyond.

o Students are writing "editorials" on word processors and transmitting them to students in other schools;

o Science classes are calling up weather services to obtain the latest meteorological data via satellite printouts;

o Teachers are sending electronic mail to other teachers in other parts of the country to find solutions to specific problems.

The number of applications of telecommunications also continues to grow. As the cost and technical barriers continue to drop, many school systems are making phone lines available in classrooms and computer laboratories. This article discusses how telecommunications is being used in education and how the change in the use of telecommunications, from a social and recreational tool to an information tool, affects teachers.

To get started in telecommunications you need a microcomputer, communications software, a modem which serves as a connecting link between the computer and the phone line, and of course, a phone line with a standard modular jack. You may also need a membership account with a "host" computer, such as CompuServe, EdLine, The Source, Tymnet or Dow Jones. If your school district runs a computer bulletin board, a membership may not be needed, only the phone number. With the account, you usually get a list of phone numbers in or near your local calling area. An excellent overview of this technology can be found in Glossbrenner (1986).

Once the technology is in place, how can it be used effectively to promote student learning? The fundamental idea behind all the applications of telecommunications is to bring the world at large into the classroom. The classroom is plugged into the outside world, an audience for student writing is available, sources of up-to-the-minute information are on-line. When the classroom computer is connected to a phone line, it is always for the purpose of calling some other computer---in the next room, in another school, in another state, or even another country.

Part of the complexity of telecommunications arises from the fact that users first have to know how to operate the software on their own computer if they are to connect with another computer; second, they have to know how to operate the computer they are calling. Although making contact with and actually operating a computer one has never seen may be intimidating to some people, to others there is a thrill in realizing that the familiar classroom computer is now a gateway to a much larger world of information. But contact is not just being made with other computers, it is also being made with other people who call the computers to leave electronic mail, articles, public domain software, and notices about important events.

Some of these connections can be made using conventional means, of course. For example, it would be foolish to pay an hourly charge to have students search a computerized version of an encyclopedia when the same material is available in the school library or on a CD-ROM. But other kinds of data bases, e.g., like those providing weather information or news, are appropriate for classroom use. They give the student access in "real time" when events occur. Similarly, if newspaper stories and editorials are being shared between only two classrooms, the conventional mail system (even for sending floppy disks containing the writing) may be a simpler, cheaper, although somewhat slower way, to telecommunicate. But if a larger network of classes is sharing their writings, it becomes far simpler to broadcast a copy of the message to all sites simultaneously. In general, the connection to the outside world via telecommunications is most effective where the information is timely and where there are a significant number of students or classrooms involved in the activity.

BANK STREET COLLEGE'S EXPERIENCE WITH TELECOMUNICATIONS

To illustrate additional principles for using telecommunications effectively, some examples are helpful. Over the last three years several projects at Bank Street College have used telecommunications both in teacher education activities and for classroom activities. We have used telecommunications to provide teacher support in two national training projects: the IBM Model Schools Project (Newman & Rehfield, 1985) and the Mathematics, Science, Technology Teacher Education (MASTTE) project (McGinnis, 1986). In the Bank Street Exchange project, we set up our own bulletin board system for use by Bank Street staff and students in the School for Children, as well as by teachers and students in the neighborhood. Another project, Earth Lab, is integrating several levels of communication -among students in a school, among schools in a neighborhood, and among cities around the world (Newman, 1986). The MASTTE project focuses on improving mathematics, science, and technology education in upper elementary grades (Quinsaat, Friel & McCarthy, 1985). The particular focus is a multimedia, integrated science and mathematics project entitled "The Voyage of the MIMI" (see pp. -). In this project teacher and support personnel from around the nation spend a week at Bank Street College, where they receive training on the content and experience with the television, computer, videodisc and print aspects of the program. They explore the theory behind the programs, planning and management of teh materials in the classroom, and discuss the integration and evaluation of the use of the materials in their regular curriculum.

Continuing support is provided through site visits to local school districts and through telecommunications. For the latter purpose The Source, one of the larger commerical systems available, with local access in all major cities is used. Because ours was a demonstration training project, our initial idea was to use telecommunications primarily for conveying information about the materials and providing ideas on how to use them. The network served this function reasonably well, but the most popular activity turned out to be a classroom activity. Guest experts, i.e., scientists and other experts featured in the television segment of the materials, answered student questions via electronic mail. Classroom time was spent in formulating student questions for the experts and later in reading their responses. The excitement and enthusiasm for this activity was very high. Based upon teacher and student data we shifted our emphasis from information to a forum for the discussion of issues related to the scientific problems raised in the program.

In this context telecommunications became a much greater classroom activity than we had orginially anticipated. Teachers specifically asked for things they could do in the classroom. We have come to believe that this medium is best used when direct classroom and student activites are derived from it. It is an ideal and cost-efficient way to provide guest experts in content areas for discussions and forums.

A very interesting result of this project arose in the guest expert series. A pedagogical goal of the MASTTE project was how to get teachers to feel comfortable about not knowing all of the scientific content. The guest experts provided the teachers with expert answers to questions students raised that teachers were uncomfortable in answering. It also made the classroom a more realistic world in that both teachers and students joined together to seek new information. The real world of science continues to push against the edge of knowledge and to use sophisticated data bases to gain access to known information, enrolling both teachers and students ways to learn from the experience in a new way.

Another telecommunication project, the Bank Street Exchange, provides a variety of writing activities for students in the neighboring schools. Some of these were modelled on similar activities pioneered by Jim Levin, Margaret Riel, and their colleagues (Levin, Riel, Rowe & Boruta, 1985; Riel, 1985). The Exchange is a bulletin board system operated on a microcomputer at Bank Street College. Several classes at a neighboring elementary school use the Exchange quite regularly. The Exchange was also opened to the public and we actually received calls from around the nation once word began getting out through the "underground" bulletin boards. Some interesting communications occurred with the children who called the Exchange from their home computers.

It is clear from the kinds of unintended conversations that developed on the Exchange that bulletin boards are part of the computer culture that have a life quite independent of schools. In many respects telecommunications is still a hobbyist activity, just as other microcomputer activities were eight years ago. Computer bulletin board operators take great pride in the services they provide. The operators have enough enthusiasm to see them through some of the technical complexities. While it helps the operator to have some of the dedication of the hobbyists, it also helps to have sufficient release time to do the job with the professionism the school district expects.

One of the activities in the Exchange was arranged with programs in San Diego. Using a process we termed "portage, " we transfered messages that New York students wrote on the Exchange to The Source (a national network) and our colleagues in San Diego "portaged" the messages from The Source to their local system. In turn San Diego students were able to communicate with the New York students. This was a rapid, cost-efficient way to use this technology. Our techniques reduced the price considerably and made it easier for schools to participate. It should be noted, however, that the program was out of sync with real-time activities; For that reason students were frustrated and never developed strong pen pal applications on the system. The system did work well when the emphasis shifted from person-to-person communications to class-to-class communications. Current events stimulated a lively exchange between the classes. The United States' bombing of Libya was the first event that stimulated opinions and discussion between the classes 3,000 miles apart. The activity was successful because the topics were compelling and generated strong feelings and opinions on the part of the sixth graders. But the structure of the Exchange was also easier to manage than was the person-to-person pen pal program. The essays between the classes were eagerly awaited by each group, and the group dynamics were such that all children participated in discussions. The individual students who ultimately formulated the actual response to the other class were closely edited by the entire class so that a greater feeling of involvement on the part of all students was created.

LESSONS FOR THE FUTURE

Our exploration showed that in the uses of telecommunications group activities were more effective than person-to-person activities. This observation was borne out in the "guest expert" activity, where little was lost if a given class failed to ask a question. and in the current event editorials and essays. These activities seemed more effective than the pen pal activity. In part this may have been a function of the difficult procedures. In the "guest expert" activity, as long as a sufficient number of questions are generated, the exchange is valuable to everyone, regardless of whether participation is active or passive. As long as there is a "critical mass" of activity, the exchange is lively and valuable to all. The person-to-person activities are difficult to manage in a classroom, and we question the effectivenss of the time required by the teacher to coordiante such efforts. There may well be some individual students who can manage this type of activity productivity.

The use of both The Source and the Exchange in our projects illustrates the most critical aspect of using telecommunications as an effective tool in elementary schools. In almost all activities, students and teachers spend a minimum of time connected to the host computer. Most of the letters, essays, and questions were composed on word processors. Once these written materials were considered acceptable, they were transmitted via the telecommunications system with a minimum of connect time. Thus, the line costs were minimal, and were, for the most part, local calls. There may be some times when long-distance calls are unavoidable, but even here it is possible to seek information from a data base and have it dumped into the memory of a microcomputer for more detailed use. Weathervision, a program by Paul Hamilton Associates, allows you to call a computer in Washington, D. C., and download relevant data to your classroom computer. Transferring the entire national weather service data for the U.S. takes only 80 seconds. Such time costs do not add significantly to your long-distance bill. Once the data is transfered, the class can use Weathervision to display maps of temperature, wind direction, and air pressure at any point from sea level to 40,000 feet. There is no charge for the manipulation of the data since it is now operating on the stand-alone microcomputer.

Although the classroom telephone line opens up a new world of information and communications, the emphasis should remain on what happens in the classroom process. Creative teachers will continue to mold the classroom lessons and discussions. The telephone and its access to information through the computer will enhance the richness of resources in the classroom. A few minutes of "data transmision" each day should keep the class occupied with communication activities that spark the students' interests and contact with the world outside the classroom.

Telecommunication resources are in the home and work place and they are slowly being applied to education programs. Hardware, software, and telecommunication services are becoming affordable for schools. Bulletin board services are proliferating across the nation. Some school systems have local area networks (LANs) to interconnect microcomputers in a school or lab. At the same time, some state education agencies are planning and implementing telecommunication systems for both administrative and instructional purposes. It is inevitable that local and state systems will evolve that are more powerful and effective, because both administrative and instructional information can be transmitted rapidly and effectively to all education institutions. Up-to-date curriculum resources can be transmitted and actually adapted for local use via telecommunication systems and desktop publishing systems.

The Earth Lab project at Bank Street College is now experimenting with integrating local and long distance science activities using an LAN within the school and phone lines to telecommunicate outside the school (Newman, 1986). Systems like Earth Lab make communication easier and more routine for the individual teacher. At the same time, they require a higher level of commitment and expertise in the school district. The Technology Services of the School District need to be more sophisticated and capable of operating more complex networked systems. The bottom line, of course, is whether these resources increase productivy in the teaching staff and result in better achievement of the students.

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INTERACTIVE INFORMATION SYSTEMS

by Frank B. Withrow

Technological innovations always alter the status quo of the institutions and people they serve, because with the introduction of technology, there is always a trade off between old and new. For example, speed and efficiency may be obtained, but skill and craftsmanship lost. A handcrafted oriental carpet may be of higher monetary value and artistic value than the same carpet manufactured by machine. However, the machine carpet may be just as functional without the cost in human effort that has been traditionally associated with handcrafted carpets. Decision makers must weigh carefully such benefits and losses when considering the introduction of a new technology. For example, the introduction of moveable type in the 15th Century ultimately introduced the most radical change in education that society has ever seen. There were libraries and books before the introduction of the printing press, but there were also gatekeepers to those books. Only scholars and scribes had access to the stored knowledge in the existing libraries. For the most part education was provided only to apprentices, who modeled their knowledge directly after master craftsmen. Scholars were few and far between -- rich, male students who could afford the time to sit at the feet of master scholars.

The printing press slowly revolutionized scholarship, because it meant that the learner no longer must be tied to the feet of the master scholar. Moveable type and the printed page offered self exploration of the knowledge base of the society and opened up the way for universal literacy. Literate people could read and understand the truths of the Bible, one of the first books to take advantage of the new technology. Ultimately, the printing press brought about the democratic distribution of knowledge for all literate people.

Robert Lewis Shayon characterizes literacy as the ability to both express and receive ideas. Traditionally, literacy has been associated with writing and reading print, but in a modern information society, Shayon's definition is much more useful. Our understanding of literacy today must be expanded to include electronic symbols as well as paperbased print. Radio, television, telephones, computers, and satellites have accelerated the ability to express and receive ideas many times over.

Through telephones and satellites, it is technically possible for anyone in today's world to "reach out and touch", billions of our fellow inhabitants of Earth. Political and language barriers, no longer prevent the spread of information. Technology can, as it did in "Live Aid for Africa," reach across linguistic and political boundaries. Today's technology is so powerful that nothing can stand in its way. Knowledge of the tragedies of the Challenger and Chernobyl could not have spread instantaneously even ten years ago, but today's international networks of satellite technologies made it inevitable that these events, whether they happened in a free or closed society , were available to the world.

Today's technology also allows us to transmit and store information at fantastic speeds, whether the messages are directed to a single person or broadcast to the world. Through the long history of civilization, the spoken word has remained the major vehicle for human communication. It is the primary way that we share our experiences and knowledge. It has been during only a relatively short portion of that history that people could store ideas in a format--the written word--that could cut across geographical boundaries and be shared with succeeding generations. The invention of photography in the 19th Century and voice recordings in the 20th Century have further extended our ability to store and retrieve information. The ability to record video in this Century further increases our resources. Technology has expanded the boundaries of the spoken word to include virtually all forms of information, and has made them available on an infinite scale. We can store and retrieve verbal, audio, pictorial, and numerical data on demand of the teacher, the learner, or any other user.

Among the most exciting of the new possibilities are components of optical storage systems: the videodisc, Compact Disc Read Only Memory (CD-ROM), Digital Video Interactive (DVI), and Compact Disc Interactive (CD-I) technologies. The standard 12-inch laser videodisc can store 54,000 single frame pictures on each side. Each picture is accessible in seconds; they can be played as full-motion colored sequences with stereo sound. Coupled with a computer, such interactive systems can enter into a dialogue with the learner. Even without the computer control, such systems offer the teacher and student access to a large visual data base. Industrial training applications of these technologies have demonstrated a wide range--from basic electronic courses to management courses. The combination of these programs with CD-ROM systems offers a new configuration of learning technology. A number of programs in science and mathematics have been used in elementary and secondary education. While these technologies are not yet widespread, there is a growing awareness of them and a number of new programs are being developed in the United States and England that can used in elementary and secondary schools.

Interactive information systems will provide the teacher and students with cost-effective educational resources; the techniques for using such resources have been developed over the past several years. The first applications of these technologies are much like reference books except that they can display print, colored pictures, audio information and full-motion sound, and simulations of real experiences. Some characterized of interactive systems are:

- o They can be either compressor expand events in time.

- o They can make micro and macro examinations of events and experiences. For example, working with an internal combustion engine can be explored through an animated voyage through its cycles of operation. The learner can direct the speed of the voyage and call upon stored information to supplement the animation.

- o Dramatization and recreation of historical events--actual footage of 20th century events--are available.

- o Simulation of dangerous or violent events can be controlled in interactive information systems.

Ultimately, as the technologies develop, they have the potential for cost reduction. Already we see the impact on such things as the *Grollier Encyclopedia*. The videodisc version is $30, the CD-ROM version $200, and the regular print version is $800. As more television systems become based upon digital design, these systems will become integral parts of home television and communication systems. The average citizen will have access to this body of stored knowledge.

WHAT HAPPENS IN THE CLASSROOM?

Teaching and learning processes will not change; what will change is that the new media will offer information data bases that are more universal. Teachers will continue to lecture and explain, and students will continue to listen and pose questions. Supplemented by books, this oral/aural model of learning will still offer both teachers and students a rich base of knowledge. This teaching method is and will remain the dominant format used in education, especially in the first three to four years, which are designed to teach the fundamental skills of reading and mathematics. These skills are the foundation for much of the subsequent learning required by our society. In a good educational environment the teacher carefully guides each learner through these skills to mastery

Obviously, in today's educational marketplace some students are being short-changed, because too large a percentage of our children do not master these basic skills. For the most part, curricula in schools today are dictated by textbooks and implemented by traditional oral/aural techniques that are too often didactic, expository monologues by the teacher. In the ideal paradigm, the master scholar sits on one end of the log and the student on the other. This paradigm is interactive; it requires questioning by both the teacher and student to nuture the student's development. Now, thanks to word processing computers, teachers are again beginning to require students to write as well as read, i.e., to develop the skills needed for interactive education. It is the interactive skills that lead to complete literacy--the ability to receive and express ideas.

One of the great challenges of education in an information-rich society is how to integrate these technologies into the routines of the classroom. Or better still, how can they be used to extend the learning time beyond the classroom. In the largest sense they represent teachers' tools that can enhance the content of the curriculum; tools that both teachers and students can use to refine and develop their understanding of a subject area They can access large data bases of visual, auditory, and digital information.

One example of this is a product on bioscience developed by Joe Clark, President of Video Discovery, Inc.. Dr. Clark was a professor at the Univeristy of Washington when he developed this product under a grant from the U. S. Department of Education. He became so impressed by this technology that he formed one of the pioneer educational companies in this field. At the finger-tip of either the teacher or student on the Bioscience disc are the requisite slides animated sequences on DNA, and actual motion sequences on cell division for use by high school or college courses. Teachers report that they and students use this resource on a daily basis looking up references to bioscience needs as in a traditional reference book. With this material they are now able to examine in detail the micro and macro aspects of bioscience.

The development of laser videodiscs, CD-ROM, and various interfaces with computers such as HyperCard enable users to index, file and retrieve a massive amount of data. Such systems move back and forth from print to picture to motion to sound and various combinations with maximum ease. With the development of digital based television, such systems will be in homes in the 1990s.. The challenge is how educators can make effective uses of these resources.

One partial example of the power of this type of hyper screen capability is being developed experimentally by Apple Compter, Inc. and Scholastic, Inc., using vieodisc and the hypercard. Such relational data bases allow the user to track through the system in an infinite array of paths that include such things as the *Federalist Papers*, excerpts from the Contra Hearings, historical footage from newsreels, and countless still photographs and drawings. A student can explore prepared explanations of the Civil War from the viewpoints of President Lincoln, or Robert E. Lee. The teacher can prepare still additional paths on the Civil War and students can be assigned reports on the Civil War from the view point of consitutional law and search the Supreme Court findings. Still other groups can have access to some of newspaper and print references of the times. Interestingly enough, the Contra Hearings are included because of the Consittution questions raised by the Civil War involving the president's authority to act. Audio exerpts from President Kennedy's telephone conversation with the Governor of Mississippi in the civil rights battles also relate to the same part of the Constitution with respect to presidential authority to act. All of these and countless other data bits are available to the student and teacher as they explore the United States Constitution.

IBM, using their InfoWindow system, developed a similar product for exhibition during the celebration of the 200 years of the Constitution. Their data base looks at many things related to the Constitution, but one that is relevant to today's issues is the 55 MPH or national speed limits. Users can explore the authority in the U. S. Constitution and court rulings.

In a simpler time we could expect our teachers to be all knowing resources of information. Today, in a given subject area the knowledge explosion is so fast that even leading experts have difficulty assimilating the developments. Therefore, it is unreasonable to maintain that expectation of teachers. They must have at hand all of the tools that can help the student acquire the knowledge and experiences needed to master specific content areas. It is important to remember that 90 percent of all of the scientists the world has ever known are alive today. No scientist today, whether medical doctor or research physicist, can hope to keep up with developments without life-long learning.

The challenge of teaching and learning in the next century will be to know how to seek out information, how to ask the relevant questions, how to use this information to express new ideas, how to find the resources available to each user. The most disadvantaged in the 21st century will be those whose access to interactive information systems is limited or nonexistent. It is essential that our schools join with all other aspects of society in increasing their productivity though appropriate applications of technology.

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INTEGRATING TECHNOLOGIES TO ENHANCE LEARNING IN SCIENCE AND MATHEMATICS

by Regan McCarthy

The preceding articles amply describe the use, power, and influence of television, computers, videodiscs, and telecommunications on what and how we learn. But what do we know of the potential of any or all of these technologies when used in combinations? Is the effect neutral, cumulative, synergistic?

These questions are neither trivial nor academic. Perhaps nowhere are the effects of technology felt in schools as strongly as when integration of components and media is the rule rather than the exception. The near future of technology appears to be moving rapidly--and somewhat paradoxically--towards both diversification and unification. The increased digital encoding of all forms of data means that all technologies will operate on the same type of input while forms of output can be highly flexible and varied: A single digitized bank of "data" could be displayable as a television show, a three-dimensional hologram, a computer-generated text on screen or paper, a sound track -- on any variety of output forms. These hypermedia formats are already being introduced in experimental programs. Our present concern about integrating technology focuses on the best ways to bring diverse sources and forms of information together conveniently and effectively. Ultimately, however, we must deal with a more fundamental question: What information is best conveyed and reinforced by which media, and how do we combine media to enhance learning most effectively?

One attempt to answer this question began in 1981, when Bank Street College received support from the U. S. Department of Education to develop "The Voyage of the Mimi," a multi-media program in science and mathematics for the elementary grades now used in thousands of classrooms around the nation. This effort has provided some idea of the uses and utility of integrated technologies in mathematics and science instruction. Much of this information comes from the work of another effort: The Mathematics, Science, and Technology Teacher Education (MASTTE) Project. This National Science Foundation project, funded at Bank Street College, is a research and demonstration program to study and improve science and mathematics instruction at the elementary level using "The Voyage of the Mimi" as the vehicle for implementation. MASTTE is now providing training and support in 14 school systems around the nation, as well as conducting research on the preparation of elementary teachers, pedagogical philosophy and practices, instructional planning, and the management of technology in mathematics and science instruction. Our early efforts convinced us that integrating media and technology brings considerably more power to learning environments. Children's and teacher's experiences seem to be more expansive, more motivating, more dynamic, and more "real" when integrating technologies than when technologies are used independently or not at all.

INTEGRATING TECHNOLOGIES: VIDEO, PRINT, AND COMPUTERS IN "MIMI"

"The Voyage of the Mimi" is a television show in two segments: 13 quarter-hours of adventure story about two researchers and their teenager assistants, who are conducting a study of humpback whales aboard the ketch, Mimi, in the Gulf of Maine; and 13 quarter-hours documentaries (known as Expeditions) which explore and expand upon concepts or phenomena depicted in the drama. Accompanying the television is a *Teacher's Guide*, an *Overview Student's Guide* and four learning modules: Maps and Navigation, Whales and Their Environment, Ecosystems, and Introduction to Computing. Each module contains print material and software for teacher and student use.

"The Voyage of the Mimi" materials reflect our thinking about how children learn to do scientific investigations, how to bring other resources to bear on this work (such as computers), and how new and varied media can improve learning. Each type of material is designed to serve a different purpose; as a whole system the materials present a cohesive and powerful combination of instructional tools.

The television series was designed to be the "prime motivator" of the Mimi materials. The theme--whales--was selected because it offers a rich vehicle for science and mathematics, because of its wide appeal to both boys and girls (and adults) in a range of grades, and because it is timely; in short, because it offers a broad base upon which to build the TV shows and related software. Further, the plot was designed to illustrate certain skills and attitudes that are a real part of "doing science." Neither the shows nor the materials discuss formal scientific processes (the scientific method); rather, they convey a disciplined curiosity about scientific and mathematical phenomena. Our belief is that most working scientists were first fascinated with a phenomenon itself (e.g., the highly publicized fascination of Stephen Gould for a snail or Lewis M. Thomas for a cell). Only later were they attracted to the tools and methods for examining the objects that caught their interest.

Similarly, we designed software programs based upon certain assumptions about the uses of technology in learning science and mathematics. First, while the shows are designed to be highly motivating, the computer is the central classroom "attention getter." The vehicle used to grasp and maintain interest in a topic or theme that the shows present. Second, all software programs contain mathematical and scientific content, although the balance of mathematics and science varies according to the purpose of the software. This composition reflects our belief that mathematics and science are partners in the work of understanding natural phenomena.

Third, each software program emphasizes a different scientific discipline (e.g., biology, geology, geography, physics) a mathematical concept (e.g., variables, angles, estimation), or both. The disciplines and concepts were selected from the obviously large number of scientific and mathematical areas for several reasons. They are appropriate for elementary students; they offer variety in content; they are adaptable to a range of software formats; and they allow us to illustrate a principle of scientific work-- that in any facet of nature many scientific and mathematical laws apply. Further, the combinations of specific mathematics concepts and scientific disciplines allow us to reinforce four general skills of scientific investigations: forming and testing hypotheses, predicting, sampling, and generalizing.

Fourth, Mimi software is designed to model software formats commonly used by adult scientists. Consequently, our four learning modules include simulations (Rescue Mission in Maps and Navigations), modeling software (Island Survivors in Ecosystems), lab instrumentations (The Bank Street Lab in Whales and Their Environment), and programming tools (Whale Search and other turtle graphic games in Introduction to Computing).

Print materials have an equally important and distinctive place in the Mimi. They provide factual information for both teachers and students, as well as suggested activities or studies. They also contain probing questions that require time and effort, thus allowing for both continuous reference and slower assimulation of information than either the televised shows or the software. Finally, the print materials provide resources and references for further investigation or study.

According to Samuel Gibbon, executive director of the project through which these materials were developed, the combination of media/technologies found in Mimi has special power to put math and science concepts and problems in "real world" contexts that are highly motivating to students. A dramatic television segment can set the problems, depict engaging characters struggling to solve them (perhaps under considerable dramatic pressure), and then play out the solution as the dramatic conflict is resolved. Documentary episodes and print materials can also provide additional information about the problems under investigation while raising questions that help formulate solutions. Microcomputer software can then present analogous problems for the student of solve.

For example, in one episode the captain of the Mimi sets a course towards a dangerous shoal. An electrical problem causes the knotmeter (a nautical speedometer) to malfunction. The captain measures the Mimi's speed by timing the boat's passage past a piece of bread thrown in the water. The calculation confirms the captain's suspicions: The boat has been traveling faster than the indicated speed and has therefore gone further towards the shoals than the capitain intended. He must quickly determine the boat's actual position. He triangulates Mimi's location by taking compass bearings with the boat's radio direction-finder: Where the bearing cross, there lies the Mimi, perilously close to the rocks. Students who watch this episode in class are absorbed by the dramatic action. Because the mathematics of navigation is central to the resolution of the problem, they remember most of the details. And, they are motivated to address the next task: to use Rescue Mission, which contains computer -simulated instruments, to solve analogous navigation problems. Although the math concepts are difficult, the dramatic demonstration of their value in a life-threatening situation sustains the students' interest through the hard work.

Later in the drama, the Mimi is caught in a storm. During the frantic efforts to take down the sails and find a safe harbor, the captain is knocked overboard. He is rescued, but the crew must immediately return to securing the ketch. The capitain is left in his wet, cold clothing for too long and attempts to raise his body temperature using standard survival techniques. This episode is followed by "Goosebumps," a documentary on the regulation of body temperature. Students see one of the Mimi crew (in his real life persona) at the U. S. Army Arctic Wind Chamber, exposed to various conditions that affect body temperature. Watching the narrator (the 12-year-oid protagonist) shiver to keep his core temeprature stable as his extremities lose heat elicits sympathy and amazement from student viewers. They become curious about their own body temperatures: Is mine the same as yours? By using the temperature probe on the computer-based Bank Street Lab, students easily obtain the answer to this question and several others simultaneously. Measuring the temperature of each student's hand using the temperature sensor of the Bank Street Lab, they quickly explore both the phenomenon itself (hand temperature), and the characteristics and functions of the Lab as well. They discover the power of this tool to calibrate, measure, compare, analyze, display, and store their data--in other words, to conduct investigations as scientists do.

As noted earlier, all software formats in the Mimi materials are designed to engage students in scientific inquiry, just as adult scientists are engaged. But the power of these materials is not only found in the way students are introduced to "real" electronic tools for scientific investigation, but also in the way all parts of these materials are related and hold together. The Mimi materials are integrated in two ways: first, in the mixture and appropriate use of each medium as each is used to present ideas, images, facts, processes, and tools of scientific and mathematical inquiry; and second, in the conceptual connectedness of the subject matter presented through all media used.

This connectedness is accomplished by use of themes--whales as the overarching theme, and broad scientific or mathematical concepts, (e.g., Ecosystems) as themes of modules. The main theme of the television series and the sub-themes of the modules, and thus of the print and software, are also related. For teachers, this thematic approach makes instruction considerably easier to organize; for students it makes learning seem more natural. With activities driven by questions about broad themes, the irregular and cognitively difficult process of moving from one discipline to the next (e.g, from reading to mathematics to social studies) is minimized.

Other efforts to integrate technology in classrooms have also shown promise. MASTTE research, for example, has corroborated the research of psycholinguists about the relation between video viewing and reading comprehension. Several large materials development projects, such as "The Search for Solutions" and "Challenge of the Unknown" have attempted to integrate two media--video and print--with considerable success. And many schools continually use materials in different media in an integrated fashion. In this regard, the advantages to using packages such as "MiMI" is that the materials are organized, simplifying planning and teaching considerably.

AND THEN CAME TELECOMMUNICATIONS

Inasmuch as the "Mimi" materials were being developed while advances in telecommunications were making them viable for classroom use, the MASTTE project seized the chance to explore the value of telecommunications, both as an instructional tool for students and as a medium of staff development for teachers. Consquently, we established an electronic conference using the PARTI system, now on the SOURCE. The activities are well described in Dennis Newman's article, "Telecommunications: A Phone in the Classroom," but some of the outcomes are appropriate to this discussion.

Networks offer teachers a way to overcome the isolation they frequently experience while teaching. They can open "closed doors" by giving teachers immediate --and controllable--access to subject area specialist, to data bases, and to other teachers who are working on the same projects or curricula, using the same materials, or who are simply interested in the same issues. Networks offer a medium for immediate feedback about materials, techniques, and resources. Further, they give teachers access to nationwide as well as local sources of information.

Students receive similar benefits. They have access to the same people and data bases as their teacher and can engage in significantly more interaction with peers. More exciting, however, is the opportunity networks give students for genuine collaboration with peers, teachers and scientists on scientific questions that are important (to all) and interesting (to them). We know that adolescent networkers are very active on computer networks such as BBS and others. Low cost, ease of operations, and common interests are aspects that make these networks appeal to adolescentss. At the present time there are no systems that are used by preadolescents and no system is readily available to them and their teachers. MASTTE's efforts identified some of the aspects of networking with elementary children that make is accessible and valuable for them to use.

FORMATIVE RESEARCH

Many of the aspects of the "Mimi" are theoretical and philosophical considerations about learning and have been translated into design features of the materials. But how do the materials fare in classroom use? Since December 1981, continuing research has been conducted by the Bank Street College's Center for Children and Technology (C.C.T) on every aspect of the "Mimi" project ---the documentaries, the print materials, the software, and the television programs. More than a thousand children have participated in the many studies conducted. The MASTTE Project also reviewed the uses of "Mimi" materials among MASTTE participants and assessed teacher support needs, particularly the integration of new technologies in instruction. C.C.T.'s most comprehensive formative effort was a classroom-based field test of "Mimi" materials (Char, et.al., 1983). The evaluation tried to answer four basic questions:

- What were the teachers' backgrounds and classroom routines prior to the field test?
- How were materials used and how easily?
- How appealing were the materials to teachers and students?
- How comprehensible were the materials to teachers and students?

Further, we addressed each of these questions from multiple perspectives, according to the perceptions of teachers, students, and our own staff of researchers. For example, in order to obtain a collective picture of student comprehension of a piece of software, teachers were asked what aspects seemed unclear to students; students were asked what questions they had about the materials; and students took a comprehension test that focused on specific software tasks that seem to be generally problematic for children.

To answer our research questions, data from seven measures were used. These covered teacher background, in-class usage, and materials evaluation; they involved questionaires, student and teacher interviews, and classroom observation. In general, we found that the television shows, software, print materials, and related activities fared well in the varied classrooms where they were used. A number of relevant findings, which emerged after a review of the data from all field tests, significantly affected our thoughts, both about staff development and about further development of "Mimi" materials.

With regard to **teacher background and preparation,** we found three characteristics that influenced how much the materials were used. First, we consistently found that the materials were used more often, and student users were more satisfied with the materials, when a microcomputer was regularly available in the classroom. Second, we found that the role teachers assumed significantly affected use. Teachers who used software only to demonstrate to students were, as might be expected, associated with a significant drop in student interaction. Finally, we found that prior experience with a microcomputer did not greatly affect software use, although the degree to which teachers themselves understood the mathematics and science concepts in the materials was highly influential.

With respect to **appeal and comprehension of the materials,** we found, again, that the television shows had high appeal, held the interest of children (and most teachers), and transmitted useful and accurate information about science, mathematics, and scientists at work. Regarding **software**, field tests demonstrated three factors that affected their comprehensibility and appeal: (1) teachers' understanding of the software itself (what it does, how it works, what concepts seem to be problematic for children); (2) the structure of the software (less structured software such as the Lab poses more difficulties regarding classroom management than more structured software such as Rescue Mission); and (3) the level of student understanding of the concepts inherent in the software, as well as the tasks required to use it effectively.

Formative research indicates two other factors that affect use of "Mimi" materials, but over which we could have little influence: (1) the science background--whether formally or informally acquired--of teachers, and (2) the preferred teaching style of individual teachers. Teachers with strong backgrounds in science and mathematics were clearly able to use these materials more effectively. With regard to teaching style, we found that child-centered teachers were more effective in using this technology than were teacher-centered teachers. Both these findings speak to the pre-service training of teachers, as well as to the general interests and preferences of individual teachers using "Mimi" materials.

MORE RECENT RESEARCH

MASTTE research generally corroborated the findings of the "Mimi" formative research. In addition, we discovered several interesting things about the use of materials, changes in teacher and student attitudes towards science and mathematics, and the effects on classroom environment. We also found some indicators of the applicability of telecommunications to elementary education.

Among our findings on the **use of the materials**, we found that teachers used integrated technologies in many different ways. Some used the video portion first, others the software, and still others the print materials. Some showed the videos slowly over time with computer -based or laboratory experiences interspersed. Still others used the materials in disciplines other than science first, for example, as a language arts experience or for social studies. These variations reflect both the versatility of the materials and the inclination of teachers to work initially in their most familiar disciplines. Ultimately, all teachers used all media and all increased instruction in mathematics and science. However, the integration of both media and content throughout the materials afforded teachers and students greater options

We also found that this flexibility helped teachers to grapple with their own limitations in science and mathematics. Many of the teachers we worked with are as naive about science and mathematics as the students they teach. (This phenomenon is not peculiar to MASTTE teachers, having been reported by David Hawkins and others who are concerned with barriers to adult learning.) Many MASTTE teachers reported excitement and surprise at their increasing interest in these subject areas. Especially significant was the ease with which some of the project's more technology-phobic teachers began to use all portions of the materials, including networking.

Students showed similar enthusiasm, largely because the materials are inherently motivating, but also because the materials allow children to do what adults do: be flexible in using resources, tools, and activities in solving problems. Students worked in all kinds of arrangements: alone, in small groups, in large groups; with teacher assistance, with peer assistance, and with expert help; with computers, with laboratory materials, and with common, everyday objects. Overwhelmingly, the feeling in the classrooms we observed was that when "Mimi" was used, it pervaded the life of the classroom. In this sense, all parts of it were integrated into the scientific and mathematical investigations underway.

We have also noticed some interesting changes in classroom atmosphere. While watching the video portions, children invariably became more relaxed. Seating arrangements became informal, occasional comments among students about events in the episode were heard, and a perceptible shift in teacher and student exchanges were seen. Since "video first" was the predominant mode of entering "Mimi" activities, this casual and comfortable atmosphere frequently led to more student -initiated activity and especially enhanced small work in classrooms.

MASTTE participants are typical of teachers in their use of and attitudes toward telecommunication networking. Once they use it, teachers frequently become enthusiastic, but getting teachers on line may take some effort.

We found some constraints to the uses of integrated technologies that are probably typical across the nation. These are: (1) declining budgets, with a resulting low priority given to innovation in school budgets; (2) lack of personnel qualified to train teachers to use telecommunications appropriately; (3) resistance among teachers to new technology; (4) the rudimentary state of communications software; and (5) the recent state of research on the effects of technology on learning. Perhaps the greatest obstacle, however, is none of these. It may be that schools lack models for evaluating their use of this technology. The availability of some of the most accessible and useful technologies (including telecommunications) for teachers is so recent that we have only begun to accumulate the research findings and the practionioner wisdom to inform us about when, how, or even why various technologies are appropriate in mathematics and science education.

The Mimi/MASTTE experiment has shown us the promise and potential of moving toward integrating technologies in the classroom. Despite the uncertainties of using innovative technologies, we have seen unquestionable benefits to students and teachers, even in these early applications. Underlying the issue of integrated technologies is another, more fundamental question about which we have only indirect knowledge: Is the medium really the message? In other words, is the value of integrated technologies essentially in the variety and flexibility they introduce into instruction, regardless of the content of that instruction, or is it related intimately to the information we are trying to convey? In the case of "The Voyage of the Mimi," it would be difficult to separate the functional benefits of the hardware from the substance embedded in the television shows, software, and print materials. As mentioned before, the relation between the content and processes were carefully considered by the developers so that a particular medium used to convey content is direct and clear. This design factor may be the reason the "Mimi" is such a strong example of effective technology and curricular integration.

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TO SUPPORT THE LEARNER:

A COLLECTION OF ESSAYS ON THE

APPLICATIONS OF TECHNOLOGY IN EDUCATION.

How does the medium effect learning?

Program Officer
Frank B. Withrow, Ph.D.
Team Leader
Technology Applications Group

Programs for the Improvement of Education

Office of Educational Research and Improvement
United States Department of Education
1989

SYNTHESIS:

TECHNOLOGY'S IMPACT ON TEACHING AND LEARNING

by Regan McCarthy

All of the articles in this section are about how technology is stretching the boundaries of teaching and learning. Each probes a new facet on this diamond-in-the-rough called "technology in education" and each reflects a novel perspective. White begins the section with a provocative piece on a curriculum for the information age. She proposes that the power of technology to transform our basic operating systems is in evidence everywhere -- in business, industry, government, medicine, agriculture -- indeed, in almost every place but schools. She calls for a full infusion of technology into the school accompanied by a revamping of our conception of curriculum.

Pogrow's ambitions for educational technology are more cautious, but no less enthusiastic. Like White, he sees technology's enormous impact on cognitive processes, but questions how beneficial technology is for average or below-average students absent careful design for its use. In his description of the HOTS program, which used open-ended computer-based activities to improve the thinking skills of average and below-average students, Pogrow relates the problems such students have in using information productively. He describes an approach that relies on strengthening students' "intellectual confidence" as a first step in improving thinking skills. Most intriguing in his programs is the distinctive rationale for using computers in this efforts: Computers make it easier for students to design inherently motivating work for themselves and to be in greater control of their own learning and thinking processes.

The behaviorial and affective responses of students to computers -- and by inference, to other technologies -- is explored fully in Gilliland's article on equity in computer education. Staning from the same premise as White that computers influence the development and application of many intellectual skills, Gilliland asserts that all of us must be prepared to deal with the demands of a technological, information-based society. Yet, evidence indicates that girls are unlikely to see the need for or value of computers in school or in later life. Gilliland describes a stimulating and successful program designed to help educators tackle head on the problems of technology phobia among female students.

Kulthau and Sherman's article takes us into a completely different arena. They describe one school system's exploration and use of on-line data bases in elementary instruction. The novel aspects of this program are the population of users (elementary grade students), the technology (telecommunications), the delivery mode (via library media services), and the eventual institutional uses of the systems (interdisciplinary studies and extensive small group work in and out of the classroom).

Finally, Mujkowski and Saunders present the TABS program, which was designed to integrate technology into three areas (writing, scientific problem solving, and learning study skills). Because the subject areas of this program do not lie within traditional disciplinary boundaries and because the planning process involved many nontechnological considerations such as curriculum revision, staff development, pedagogical change, and rearrangement of the physical plant, the TABS experience illustrates a broader range of the effects of technology on schools.

COMMONALITIES AND CONTRASTS

Although these articles address diverse interests in and approaches to using technology in education, all speak in some way to the fundamental issue of change along four dimensions: what is learned, how, by whom, and where.

WHAT IS LEARNED?

White's article, the one theoretical piece in this section, pursues most vigorously the ramifications of technologically induced changes in what is learned. Having set the background by describing the transformations wrought by technology in diverse workplaces, she asserts a fundamental premise: Not only does technology organize work differently, it also changes the cognitive demands of the workplace. She challenges schools to bring technology into the basic processes of teaching and learning, suggesting five specific processes that have undergone changes and that should form the basis of a new curriculum: planning, communication creative expression, information access, and information management.

While the first three have cognitive connotations that are easily described, the latter two might seem to be external to the learner and much more a consideration for hardware or software. Not so, however; information access and management get to the heart of both a psychological and a curricular matter: the formation of memory.

The five areas that White suggests are undergoing change are addressed by some or all of the other authors in this section as well. Pogrow, for example, speaks directly to the issue of memory formation and more indirectly to planning and communication. Mojkowski and Saunders also deal with the question of what should be taught, but in a very different way from White. While White presents technology as the driving force behind curricular reform. Mojkowski and Saunders see technology being driven by a strong curriculum and the needs of students, a direction that takes advantage of opportunities afforded by technology. In one sense, all these authors agree that technology is a catalyst for reconsidering what is important for students to learn, both in terms of content and processes.

None of the authors suggest radical changes in curricular content, although they differ on the degree to which technology -- mostly in the form of programming languages -- should become a subject area for all students. However, several authors point to the multidisciplinary aspects of curriculum development that technology encourages. Pogrow's notion of "linkage" points to cross-disciplinary curricula, while Kulthau, Sherman, Mujkowski, and Saunders give numerous examples of how traditional disciplinary boundaries can be crossed effectively.

Gilliland's article forcefully states the importance of addressing attitudes and beliefs about technology through instruction and other activities. She neither overdramatizes nor understates the dangers inherent in failing to deal with sexism, racism, or classism associated with computer use. While Pogrow deals with a different realm of attitude, he, too, is clear that behavior and attitude are appropriate grist for the instructional mill.

Beyond attitude and beliefs, Gillilan identifies an important issue for a curriculum in a technology age: evaluating information. While Gilliland places evaluation in the context of dealing with biases and prejudice, others, including White, Pogrow, and Kulthaus and Sherman place evaluation squarely in the context of "orders of magnitude," that is, knowing whether information is reliable and accurate as well as knowing when enough is enough.

How Learning and Teaching are Changing

These activities also underscore the shifting balance and boundaries between content and process. Indeed, according to both White and Pogrow, one of technology's contributions to curriculum may be to make "process" a content matter. Thus, such skills as managing information or fully using imagery may be the objects of direct instruction (i.e., content), as well as cognitive functions (i.e., processes).

Technology has suffered as the opportunity to make other shifts in teaching and learning as well. First, the classroom now has available to it a wider array of tools using diverse modes of presentation. Although not discussed in great detail by these contributors, others (e.g., the Newman and McCarthy articles in chapter 1) discuss the uses of integrated technologies in instruction and explore the role and effects of video, print, software, and telecommunications, both alone and in combination. The infusion of technology into classrooms also afford teachers and students a wider range of choice using computer-based and noncomputer-based activities. Mojkowski and Saunders are especially clear on the choices these options afford and require us to make. So, for example, it may be best to use a computer-based simulation of westward migration in order to understand the effects of weather on survival, while understanding human aggression may call for noncomputer-based simulation of a group stranded on a mountain after a plane crash. Gillilan's example of noncomputer-based activities as precursors to computer-based activities illustrates this point well.

Second, technology has given greater control of and involvement in learning to students. Pogrow, Gilliland, Kulthau and Sherman and Mojkowski and Saunders provide distinctive examples of how changes such as access to data bases, self-monitored drill and practice, and small group work have given greater freedom and responsibility to children to organize and complete instructional activities.

Third, technology has made teachers learners too. Gilliland's emphasis on the importance of computer competency among teachers typifies this phenomenon. In order to make wise choices about the uses of technology as well as to manage technology efficiently in instruction, teachers had to be comfortable with hardware and software. Further, familiarity with basic maintenance procedures and technological vocabulary help teachers feel more competent about using technology. Several of the authors indicate the necessity and benefits of carefully planned programs of staff development concerning technology.

Who has Access to Technology?

The power of technology to extend the boundaries of the classroom is obviously dependent upon access to technology. Gilliland speaks to this issue directly in her discussion of equity in computer use. The pattern of computer avoidance among females is a loss both to the students themselves and to society as a whole. There are others who are not getting a fair share of computer education. Minorities, nonEnglish speakers, and the handicapped may also not be using computers effectively. In addition, such students also have consistently fewer resources at home, which only widens the gap between technology "haves" and "have nots."

While the socio-economic issue of access to technology represents one level of the question "who?" the question pertains to several other levels as well. First among these, is the question of disabled learners. Despite Pogrow's concern for below average learner, none of the authors, surprisingly, address the issue of access to technology by handicapped students, nor is the most typical technology-related problem in schools--limited time or line--given such attention. Gilliland, however, does make an interesting and important comment about the relation between teacher competence in using computers and students' access to the technology. Clearly, educators who are facile with technology use it more often and to better effect than do those who are unprepared to do so.

Where Will Learning Take Place?

Kuthaus and Sherman raise the issue of where learning (and teaching) will occur in their articles on library-based use of on-line databases. One of the greatest challenges to the traditional concept of school is presented by the introduction of speedy systems of information access and transfer, especially via interactive telecommunications.

One of the questions the authors raise directly and by inference is the grade level at which various technologies should be used. White gives examples of grade-specific uses, with most beginning in the middle grades or higher. Kulthau and Sherman's article expresses the experimental quality of using on-line data bases in elementary schools, and thus by inference, the more obvious value to older students. None of the authors proposes uses of computers with very young children, although the debate continues on this subject (cf. Cuffaro).

SUMMARY

The articles in this section can be distinguished from articles in other sections of this work by the "cross-overs" which they encourage or describe: Crossing over disciplines, grade levels, teaching practices, content and process, and the physical limits to the classrooms. They represent a small, eclectic segment of the approaches and activities that technology affords both teachers and learners. They also speak to both the creative, diverse applications of technology in schools, and the unresolved issues that users of technology in instruction experience regularly.

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A CURRICULUM FOR THE INFORMATION AGE

by Mary Alice White

Each social institution and work setting relies on particular processes that are central to its operations. Financial institutions rely on the speed of processing market information; medicine relies on the analysis of data to arrive at a diagnosis and treatment plan; lawyers rely on access to prior court decisions and common law for legal precedent; science relies on the collection of multiple observations to establish meaningful patterns; media rely on speed of access to a newsworthy event, and speed of its communication to an audience.

Education too, relies on students' acquiring information, analyzing it, and the communication skills needed to share it. But the information technologies in these other work settings exhibit a pattern that shows a striking difference between their use of technologies and the way education uses the same technologies. This essay examines five processes that lie at the core of the information age and imagines what it might be like to install them at the core of an educational curriculum.

PROCESSES CHANGED BY THE TECHNOLOGIES

1. *Planning*

Planning is a critical process in many settings, whether it is financial planning, strategic planning, operational planning, logistical planning, or political planning. Planning changes, depending on whether it occurs in banks, investment houses, the military, the Federal government, corporations, small businesses, universities, or State governments.

Planning has been radically altered by the introduction of computers and spreadsheet software. It is now possible to see--actually see in numeric form--the impact specific change in one variable will make on a host of others, projected into the future.

2. *Information Access*

Speed of Transmission of Information. Members of the financial community rely on the quickness of information to make their decisions as we saw in the October 1987 stock market decline. Obviously, up-to-the-minute worldwide financial data bases offer traders an enormous advantage. In fact, there is some concern about whether such instantaneous information should in some way be controlled because of its ability to cause a wave of institutional buying or selling on Wall Street and other world markets.

The media depend upon speed of transmission to receive and broadcast the news. Politicians are anxious to be seen and heard on the media as speedily as possible after a newsworthy event. Instant information is the currency of electronic media.

Size of the Pool of Information. The three most frequently used information technologies today are word processing, spread sheets, and data bases.

Electronic data bases have transformed the extent to which we can access information. In law, for instance, a data base makes it possible for lawyers to search for previous decisions in a few minutes by typing in key phrases of the legal points of interest. In medicine, a physician can type in the symptoms of a patient, and receive possible diagnoses within seconds from a data base that incorporates medical knowledge and experience far beyond that of the user. Reporters in media, or writers, can search a data base of newspapers and magazines to find, instantaneously, the background of the person or subject in which they are interested.

Ease of Reference. Tapping into a data base would not be practical if it were not convenient. The availability of a computer and a modem means that information can be brought up on the screen quickly and easily (although some data bases are still unnecessarily difficult to navigate). Instead of traveling to the appropriate library to search for the relevant books, a scholar can call up an exhaustive list of references on a monitor in a few minutes and decide which are worth pursuing.

3. *Information Management*

Among the needs of many institutions and work settings are the processes of storing information, analyzing what is stored, and representing that information in meaningful ways. These information processes are central to any setting that must work with large amounts of data.

Information Storage. In agriculture, there is a need to store large amounts of information about the condition of crops around the world, seen from space; businesses must store information about their customers and their suppliers; the Federal government cannot survive without storing huge amounts of information about taxpayers; scientific research cannot progress without large pools of recorded information.

For all of these settings, the process of storing information has been transformed by the use of computers, from large computer systems to many small microcomputers connected to mass storage devices. The new laser systems for storage are providing a new and cost effective massive storage system for all types of computers including the CD-ROM.

Information Analysis. Information that is stored needs to be processed. Large amounts of data are now analyzed by computerized statistical methods to show trends and differences between groups of data. Information analysis can also compare information from several data bases so that, for example, an individual's credit standing can be compared to a record of purchases, phone calls, passport visas, and voter registration. While this represents a resource for some it also raises major issues of privacy, which as a society we must resolve.

Representation. Because computers have made the storage and analysis of mass data possible, more numeric information has been made available than the human mind can comprehend easily. One answer to this problem has been the development of graphic and pictorial (iconic) displays of data. These represent a large amount of numeric information in graphic form, in pictures of trends, in three-dimensional figures for engineers and architects, in visual displays of observations that produce meaningful patterns to the informed eye. It is ironic perhaps that the computer's ability to produce masses of numeric information has resulted in the use of imagery to help humans understand what the computer can produce. The great number cruncher now needs an image maker.

4. *Communication*

Just as information itself has changed, as well as access to it, its storage, analysis, and its representation, we also are finding that the nature of communication is changing with the new information technologies.

Many writers and journalists have found that the word processor is a better writing tool than a typewriter or a pencil because it is easier, faster, more flexible, and produces perfect copy for almost anyone. Salesmen, businesswomen, writers, and journalists find that portable computers give them constant writing power and constant communication with a home office.

Graphics made possible by software programs mean that authors can easily add graphics into business reports, presentations, letters, and newsletters. Desktop publishing puts the power of the printing press into the hands of any individual with software programs that lay out a page, allow one to insert graphics and pictures, change type styles--in fact, do virtually anything that a printing house would do.

Communication from one computer user to another is also available, either through a local network or through one of the many commercial or scientific networks now operating. Through a modem and a phone line, a computer owner can communicate with any other similar owner, almost anywhere in the world. We are also seeing the growth of teleconferencing, both audio and video, with the economics showing promise of making these feasible for everyday transmissions.

The burgeoning world of pictorial communication via television, film, and videotape is being transformed by the availability of videotap players, of video cameras, and of new electronic cameras that display still photographs through our television screen. By the mid-

1990s or earlier, digitized home television sets will have the potential for becoming the center for home communication systems. They will provide us with the images and sounds of television, still images, screens of text, stereo sound, telephonic services, all controlled by our computer. Such hypermedia systems are already available in prototypical research formats. The digital design will increase the ease of manufacturing, increase the capacity and power of the systems and reduce the cost. Within our home communication system all of the pictorial processes of the home entertainment industry and graphic, text, and statistical resources of the business world will be available.

It seems clear that how we communicate is being changed rather quickly, whether the communication serves industry, the scholarly world, or the entertainment world; whether used by writers, journalists, graphic artists, or researchers. Communication is becoming faster; it can reach more people, and it can communicate in print formats, numeric form, graphic form, or as imagery.

5. *Creative Expression*

Graphic artists have found tools of enormous power that make animation a simpler process or that give the artist power to create, on screen, a range of visual effects that would have been too time-consuming by hand. Musicians use music synthesizers, which can imitate the sound of any instrument, in any combination, to write music more quickly and easily. The more sophisticated of these music synthesizers have even found their way to the stage of Carnegie Hall.

SIGNIFICANCE OF THESE CHANGES IN PROCESSES

The significance of the change in communication technology is not just that the work is being done differently, but that the processes involved in the work are changing; people now have to think differently about how they do their work. The mental operations involved are changing as information becomes more accessible, faster, and of greater magnitude. How we think about a problem changes when we can view the problem through imagery. Masses of observational detail turn into a trend or pattern, when projected graphically.

EDUCATIONAL PROCESSES CHANGED BY THE TECHNOLOGIES

How are these technologies changing the work of education? Our public schools have installed computers, bought software, trained teachers to use computers, installed computer laboratories, and initiated classes in computer programming. A few have bought video disc equipment, video cameras, and modems, and have joined networks.

Is there a difference between what is happening in education compared to other work settings? The answer is a definite "yes." The difference is that while other institutions and work settings have adopted the technologies into the heart of their functioning, and the technologies, in turn, have changed the nature of work, *education has not changed a single basic process that is essential to its operation.* Education has kept the technologies away from the basic processes of learning and teaching. In general, software is used in schools for drill and practice. Educational software is used either for peripheral work for the gifted, or remedial work for the slower students. The continuing work of mainstream education has remained largely unaffected.

It is true that schools have lacked sufficient money to invest in technologies. But the real problem is not money. The real problem is that educators have not seen that the information technologies are just as central to the operations of education as they are to business, research, or the arts. Without that understanding, there can be no conceptual framework for the role of technologies in education. Without the conceptual framework, there has been no commitment to invest in the technologies as a rational educational investment, nor can there be one.

The basic processes of education include acquiring information, developing communication and cognitive skills, and installing attitudes and behaviors in the student. The information technologies are superb at information access, analysis, and organization. They have large communication capacities and have considerable potential for helping the learner to acquire certain cognitive skills. Yet we find the technologies inserted around the edges of the curriculum, with students typically assigned 20-40 minutes a week to a computer laboratory. The rest of the curriculum stays the same. It is taught and tested the same way, using the same type of textbooks that merely add a little software at the back.

A CURRICULUM FOR THE INFORMATION AGE

What is the answer for education? Let us recall how other institutions and work settings have used these technologies to see what might be learned. We have seen that the following processes have undergone fundamental changes:

- o planning,
- o information access,
- o information management,
- o communication, and
- o creative expression.

My argument is not that schools should imitate the workplace in their uses of technology. My proposal rests on a different argument; namely that since many institutions and work settings have found their basic operations transformed through the use of technology, doesn't it make sense for schools to ask how they can transform their environment? If the job of schools is, minimally, to see to it that young people acquire information and certain communication and cognitive skills, do these technologies offer any learning or teaching value for these basic processes? The essence of these technologies is intellectual. They change how we carry out our mental operations. They are cognitive tools They are, as Judah Schwartz has put it, mind amplifiers.

These technologies change the nature of information itself and how we represent it. They change how we view information cognitively. These changes are at the very heart of teaching and learning and might well be called "learning technologies." Educators must come to recognize that information itself is changing. That very change relies more and more on imagery for displaying complex concepts. Information and communication are part of the basic curriculum. The ways these are taught should be basic to education.

What would happen if education put these five processes at the core of a curriculum for the information age?

1. *Planning*

At the appropriate age, perhaps as early as the fifth or sixth grade, students could be learning how to use planning as a cognitive skill in combination with spreadsheet types of software. Students do not need to be taught how to project a business plan, or a profit and loss statement. But they could quite appropriately project demographic changes in their city or village and plan how to deal with the anticipated results. If students learn the history of their State and town (and they should) should they not also learn about its projected future? Could they not also project occupational supply and demand, which may influence their career choices? Could they not learn to plan their own expenditures, and see--literally--the impact of a change in one variable on the total budget?

2. *Information Access*

Students need to know how to access information through the information technologies, but they need to learn how to do so with some judgement One problem with speed of transmission is the illusion that the most recent is the best, or most important, or most accurate, which is not necessarily true.

A second problem is that only recent information is typically available in data banks, although this will change in time. If students access information at present, they will receive an inflated view of the past few years, and run the risk of developing a distorted historical perspective.

Data bases are useful tools to students, which they need to know how to search--a fairly complex cognitive process. It requires both a conceptual schema or series of schemas around which information can be organized and at least some grasp of the scope of the information that may be available. If well taught, the schema should be linked to the ways the data base is categorized: to its "search terms" or "key words." This activity would be appropriate for slightly older students, perhaps no sooner than late elementary or junior high school.

Knowing how to access information from a variety of data bases means that students could learn how to use a wide range of reference materials, including computer data bases, CD-ROM discs, and video discs. Knowing how to use reference sources is the beginning of learning how to check the accuracy of information, and how to look up what one does not know, which are both very good ways to learn on one's own.

One of the more troublesome problems about information is that many students do not know strategies for determining what they have not yet learned, because they do not know how to categorize or select the appropriate search terms. The problem is similar to the one the student faces in using a dictionary to look up a word he doesn't know how to spell. It can be done, but the student has to learn the strategies. In short, learning how to access information is a major educational process, one that will be educationally useful the student's entire life.

3. *Information Management*

Learning how to store information, analyze it, and represent it to others are basic skills for the information age. They are also basic educational skills. Students need not create and store vast quantities of information, as do research scientists, but they do need to know how to store information relevant to their own education.

Students shortly may use their own computers to store school-relevant information. Meanwhile it would be useful for them to learn the skills for storing information so that it is easily retrievable. Learning this skill is likely to increase the amount stored, and to increase its accountability, both extremely useful skills in successful education.

The analysis of information is another essential skill, both for the workplace and for education. Students could learn how to use statistical software to analyze information from social studies, science, or mathematics, so they develop an appreciation of how to treat mass data, and how to make meaningful comparisons.

The representation of data is a new skill, becoming more important as the human mind reaches the bursting point in trying to comprehend thousands of pieces of data. The representation of numeric information in iconic form is an important new communications skill, and it seems appropriate that students learn how to communicate information iconically, graphically, and with mapping techniques. Software is available that makes such tasks feasible. But schools need to go beyond these information management skills to deal with information itself--what it is, how is it changing, and how to evaluate it; this will be discussed below.

4. *Communication*

One of the major tasks of education is to teach communication, a cognitive skill. A powerful tool for written communication is a word processor, which has been demonstrated to improve the speed and ease with which students revise and publish their work. It seems obvious that this tool should be made accessible to students who are expected to write well and who face time constraints. It also seems obvious that children who are no longer learning basic concepts from the kinesthetic experience of applying pencil to paper and who are frustrated by messy results should be encouraged to improve their conceptual and composition skills by using word processors. If writing as practiced in the information age were taken seriously by educators, we would see many more word processors in classrooms, where the children are, not off in a laboratory.

When we turn to pictorial techniques of communication, we step into the world of imagery. Imagery dominates all of entertainment; delivers the news; carries political messages to voters; advertises what to purchase; sets fashions; probably transmits values through modeling of behavior; portrays occupations to young viewers; accentuates the glory of sports and entertainment figures; implies what is appropriate sexual behavior; and depicts family and home life. Reading that sentence over is itself a lesson in how television has become the prime educator of attitudes and behavior.

Education for the information age takes on a special role in teaching students how to "read" images, a skill integral to creative expression.

5. *Creative Expression*

Music is certainly being made easier to learn with the new software programs now available. Notation can be learned more easily with technology, composing is easier, music editing is easier. In the field of graphic arts, software within reasonable cost now makes page layout possible. Graphic data bases are numerous; creating graphic designs and art has become a serious undertaking. Each could appropriately fit into the curriculum. It seems obvious that schools should take advantage of this principle: when something can be learned more easily through technology, schools should use it.

COMPUTER INSTRUCTION AND THINKING SKILLS

by Stanley Pogrow

INTRODUCTION

Increasing concern about the development of thinking skills has led to a growing interest in exploring how computers can be used to enhance such skills. Can software that is not content-specific teach thinking skills, or should districts interested in using computers to enhance cognitive development stick to using them for drill and practice? If open-ended software can develop thinking skills, under what conditions is it likely to do so? To some extent, the concern over the degree of structure in computer activities reflects the larger debate about direct instruction versus discovery learning.

STRATEGIES FOR USING COMPUTERS TO DEVELOP THINKING SKILLS

Most attempts to use computers to produce measurable gains in thinking ability have focused on using open-ended software. Although open-ended software does not "teach" a specific content unit, it can be used for a variety of educational ends. Such software includes: (a) programming languages such as BASIC and LOGO, (b) word processors, (c) simulation programs, and (d) software that teaches specific components of thinking.

Most of the current use of open-ended software involves occassionally exposing students to it in the name of computer literacy, combined with some lip-service to the belief that such use will produce cognitive gains. More intensive use of open-ended software is usually expected to increase thinking skills.

There are two basic approaches to using open-ended software intensively. The first uses software that involves higher level thinking skills, such as "Rocky's Boots" or programing language, without worrying whether it is integrated into the curriculum. The second tries to integrate the software into the content of the curriculum. For example, programming can be integrated into mathematics instruction by having students write programs to solve problems. Simulations can illustrate concepts in a wide variety of curriculum areas.

Those who advocate the integration approach suggest that it provides the additional benefit of directly reinforcing the content the school is trying to teach. The rationale for using computers to teach the various components of thinking, e.g., memory enhancement, analogies, figures rotation, and mnemonics, is that integration is the best way to develop overall thinking ability. Unfortunately, research to date questions the validity of the argument, particularly for the average to below-average student. (For a review of the research in this area, see Pogrow, 1986.)

The apparently poor results from using open-minded software have led its advocates to argue either that (1) research cannot measure the benefits, or (2) that the activities enhance future employment opportunties or increase motivation and should not also be required to produce cognitive gain. Alternatively, it is possible that the failure to produce measurable gain has resulted from a naive advocacy that was not followed up with systematic program development, or from development based on the wrong theories. It was the belief that systematic use of open-ended software *could* produce measurable cognitive gain, even with average to below-average students, that led to the development of the HOTS (Higher-Order Thinking Skills) program.

In its current form the HOTS program is used with Chapter 1 students in grade 4-6. Participants in the pull-out program spend at least 30 minutes a day in a computer lab equipped with Apple IIe computers and peripherals such as robots and color printers. The program has a structured curriculum using commercial software that requires students to formulate and test problem-solving strategies. The curriculum is based on theory that computer activities to teach higher-order thinking skills can motivate and challenge Chapter 1 students and improve their problem-solving abilities, leading to growth in basic skills and social interaction. Although it is still too early to pronounce the HOTS program a success, the results are very promising. The goal is to challenge the students intellectually in ways that not only improve thinking skills, but also enhance basic skills and social confidence. HOTS activities are based on information processing theories of cognition.

INFORMATION PROCESSING APPROACH TO COGNITION

Information processing theories of cognition seek to understand how the mind processes information when an individual engages in various forms of problem solving. There appear to be at least two different types of memory function in the human brain. Short-term memory is used to recall a few recently acquired facts. Research indicates that seven, plus or minus two, is the maximum number of facts that most individuals can receive, process, and remember at any one time (Miller, 1956). Long-term memory consists of networks of associations, which enable an individual to recall and apply large amounts of information once a network has been triggered.

Little is known about the specific mechanism by which a piece of information from short-term memory is retrained in long-term memory and is attached to existing networks, or is used to rearrange existing networks and form an entirely new one. The fact that such a process goes on, however, suggests that a curriculum designed to help students learn the process of linking concepts would be beneficial. First, the information processing approach suggests that a curriculum should focus on building linkages among concepts rather than on developing new knowledge or introducing new concepts. Second, the students we observed seemed not to understand that they were supposed to create associations among concepts. Third, the coexistence of rote and networked memory in the brain suggests that instruction might successfully combine a highly prescribed direct learning approach in the classroom with more open-ended learning in a computer lab.

THE IMPORTANCE OF INTELLECTUAL CONFIDENCE

Students have many problems in using information productively. These include: (a) failure to link ideas, (b) lack of confidence in their ability to generalize or synthesize, (c) failure to think through the consequences of their ideas and reassess them when new data are presented, and (d) fear of articulating their ideas publicly. It is not that they are incapable of doing things: It is mostly that they do not seem to realize that it is important to do so. Under such circumstances teaching more content, or teaching the same content over again, is not likely to have any impact on their overall school performance.

For this reason, the HOTS program was designed to focus on "intellectual confidence." Simply stated, intellectual confidence is: (a) a conviction that one has the ability to figure things out and that thinking is a pleasurable experience, and (b) a willingness and ability to articulate ideas. There is clearly a behavioral aspect to building such confidence. Our aim was to challenge the students intellectually by maximizing the linkages around tasks. We structured tasks that they would find intriguing enough to want to think deeply about. This goal is one for which the computer offers three distinct advantages: (a) the computer makes it easier to construct such intriguing tasks, (b) students can test out the consequences of their ideas at their own thinking pace, and students can explore ideas in private while their sense of confidence grows.

There was no illusion that the program would increase students' intelligence or turn them into mathematicians or scientists. Rather, it was felt that all students had the potential to achieve at higher levels if the computers could help remove the information processing blockages they were experiencing. Therefore, HOTS focused on developing linkages that would enhance the most generalizable thinking skill of all--the ability to make inferences around the use of language.

CURRICULAR ASSUMPTIONS

Rather than assuming that students would spontaneously develop linkages, or placing the burdon on teachers to figure out ways to develop linkage ideas, HOTS provided a detailed curriculum, including a day-by-day script for the lab teacher built around the use of commercially available software. In developing a curriculum to facilitate the construction of linkages, we made the following assumptions:

1) It is more important to link concepts across different computer programs, and thereby remove concepts from their contexts, than it is to link concepts to specific objectives in the curriculum;
2) Linkages should be made around concepts that students are familiar with or those from the regular curriculum, rather than around "computerese" concepts;
3) Linkages can be made using three techniques: First, taking a concept from one computer environment to another; second, exploring the relationships and analogies between terminology in the software and in other contexts; and third, combining concepts from different symbol systems to perform a task, e.g.

controlling a robot, which involves using math, text, and phonies to make it move and speak.

4) Making linkages can be facilitated by using simple software and accessories such as added memory, mice, printer switch boxes, etc., to make using the computer as simple as possible. Complex software, such as Logo or "Rocky's Boots," requires the learning of many new procedures that have little potential for generalization;

5) The process is more important than the product. Learning situations where linkage and articulation are required are inherent in the process students have to engage in to use the computer. Cognitive growth is produced by these incidental linkage and articulation activities, which need to be planned and spelled out in a curriculum.

6) Where linkages are made to the regular classroom curriculum, it is more important to focus on the information processing activities of synthesis, integration and comprehension of the content being linked to, than to worry about linking to most of the content units for their own sake. In the HOTS program the classroom teacher assigned two to three days worth of reading in a content area and had students write eight questions and answers, which were then brought to the lab where the information was "taught" to the computer. This procedure converted the information into a game or product of some sort. Reformulating content in this way gradually built up the students' ability to work with large blocks of information.

LESSONS LEARNED FROM THE HOTS PROGRAM

The first major finding was that it takes extensive amounts of time to produce results. Students in the program were pulled out to the computer lab for at least 30 minutes a day, four days a week. It still took two to three months before students began to take responsibility for their ideas and stop asking the teacher for help every time they ran into a problem. It therefore appears impossible to develop cognitive abilities from the prevalent model of computer use where students are rotated in and out of labs occasionally.

Another finding was that if teachers are to use open-ended software effectively to improve thinking skills, they must learn to teach in a different way. One problem is over-teaching. There is a tendency to tell students what to do before they go to the computer, or to ask lower-order task-specific questions -- such as what key to hit. This eliminates the need for students to figure out what to do from the words on the screen, along with an important benefit of the computer environment -- developing reading comprehension skills.

A second problem is helping too much. The minute a teacher answers a question about what to do when the information is on the screen, or tells students the right cnoice from a menu, the lesson ceases to be one of higher-order thinking and becomes one of following the teacher's instructions. Teachers must be trained to go through the "earmuff stage," where they simply ignore the constant pleas tor help. Gradually, students begin to think on their own, and to move toward intellectual confidence.

The third major problem is that teachers tend to be judgemental. When a teacher tells a student whether a strategy was any good the lesson ceases to teach the information processing skills of making, testing, and validating decisions. Students need to collect data on the success of their strategies, and compare current results against those produced by former attempts and to the results of other students. Learning how to determine when your strategy is good or when it needs some rethinking is one of the most important and generalizable thinking processes.

A fourth problem is that students are very successful in conning or pressuring teachers to modify their questioning so as to make class participation simple. In order to counter this, it became necessary to train teachers to: (a) ask higher-order questions without giving hints in the question, (b) wait for student answers, (c) accept a logically consistent answer that is not the intended answer. The thing learned from HOTS, however, was that most of the students were far brighter than people gave them credit for, and capable of responding to more sophisticated intellectual challenges than schools currently attempt.

IMPLICATIONS OF THE HOTS PROGRAM

Our experience suggests that schools should focus computer activities involving open-ended software in one or two areas only, more away from integrating the use of computers into all areas of the curriculum, and stop trying to make all teachers computer literate. Using computers to produce cognitive gain is possible, but far more difficult and subtle than has previously been assumed. Curriculum development should not focus simply on how to use software, but on using it to create linkages. Such teaching and curriculum development techniques can usually be expected to take at least six months to a year, and should predate the actual introduction of computer use.

The open-ended teaching and learning techniques used in this program operate synergistically with direct teaching and drill and practice approaches in the classroom; students move between the two environments very easily. The drill from the classroom provides automated recall of facts around which networks can be formed, while the lab activities provide students with the skills of efficiently assimilating new information from the classroom into existing networks in their minds.

Although the development process is difficult and time-consuming, the potential rewards are great. Watching students gain confidence in their ability to think is one of the greatest joys that a teacher can have -- particularly when such a perception is based in reality. Whenever I start asking myself if all the work with this program is worth it, I flash back to the little girl who told me that no one had ever asked for her opinion before and that she found such questions strange, but then added with a look of determination, "but I think I like it."

Educators need to forget how they are "supposed" to use computers and begin to develop and test approaches that are well grounded in cognitive theory, with carefully designed curricular and pedagogical systems. The HOTS program is one approach with promise. Other approaches remain to be discovered, but experience with HOTS indicates that certain factors will remain constant: the high quality of teaching required, and the extensive time needed to develop materials and teach competence. The challenge remains -- to discover and implement alternative ways of using computers to enhance thinking.

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CURRICULUM DEVELOPMENT FOR EQUITY IN COMPUTER EDUCATION

By Kay Gilliland

SCHOOLS MUST PLAY AN ACTIVE PART

Half the working people in the United States are women, yet despite the fact that all citizens will need some understanding of computers to develop the intellectural skills now being influenced by computer use, and to perform well in the increasing number of careers that depend on computing (Clarke, 1986), girls in school today generally do not believe computers will be useful to them; they do not expect to like computing, and they see the use of computers as a male-oriented activity (Collis, 1986; Hess and Miura, 1984; Kreinberg and Stage, 1983). If these perceptions are to change, the schools must play an active part.

SCHOOLS NEED TO REEXAMINE THEIR APPROACHES

However, in one disturbing study of school-based computer learning, girls who took a required school computer course had even more negative feeling toward computers upon completing the course than did girls who had not taken the course. Boys who completed the same course were significantly more positive in their attitudes toward computers than were boys who had not taken the course (Collis, 1986).

Clearly, we need to reexamine our approaches in education. We must develop courses to maximize computer experience for girls, develop girls' awareness of the need for computing skills, highlight the contributions of women to computing, and present opportunities for girls to learn through their strengths and extend that learning to mathematics and science, where they are also underrepresented. We need to provide administrators, teachers, and other curriculum developers with the broad background of information required to design courses that will provide positive experiences for students who may not otherwise learn to use computers effectively. If girls are school-dependent for this learning, we must ensure that school courses are highly motivating. They can learn and will need this powerful new technology; we in the schools must not fail them.

INSERVICE FOR CURRICULUM DEVELOPERS

EQUALS in Computer Technology is a 30-hour inservice program for administrators, teachers, and other K-12 curriculum developers who are concerned about equitable computer education in the schools. It is specifically designed to help educators plan curriculum and instruction to intervene in the pattern of computer avoidance by females and underrepresented minorities. EQUALS has served more than 10,000 California educators and 6,000 educators in 34 other states since its inception in 1977. These mathematics workshops provide strategies and materials that encourage all students, but particularly females and underrepresented minorities, to recognize the value of mathematics, enjoy the study, persist when the going gets hard, and continue in math-based fields.

Computers were always part of the EQUALS mathematics workshops, but participants requested a much more comprehensive course with strategies for equitable computer use in all subjects. They were finding many of the same pressures against girls' computer participation in their schools as they had encountered in mathematics education. In addition, they were concerned that, without intensive staff development, the knowledgeable teachers in educational computing would be almost exclusively male, and thus the schools themselves perpetuate the impression that computing is a male field.

Therefore EQUALS in Computer Technology (EQTEC) focuses on the development of awareness, competence, and motivation through activities that are valuable to administrators and teachers, and that can become part of the regular classroom curricula for students.

AWARENESS IS A FIRST REQUISITE FOR CHANGE

Awareness is a first requisite for change and therefore an important strand throughout EQUALS in Computer Technology. Activities that help create awareness include Startling Statements,* Classroom Research, Software Evaluation, Logistics, Strategies, Historical Landmarks, Computers in Careers, and Role Models.

<u>Startling Statements.</u> In Startling Statements, participants explore the answers to such questions as:

What percent of home computer users are male? (90 percent)

What percent of BYTE Magazine subscribers are female? (5 percent)

Women are 4 percent of all electrical and electronic engineers; what percent are they of the computer data entry operators? (92 percent)

What becomes clear from the Startling Stements activity is that women are not participating in the computer revolution. Recognizing this, educators are more likely to plan curriculum that will motivate girls to use and enjoy computers.

*The off-line activities described in this article have been published in **Off and Running** by Tim Erickson, Lawrence Hall of Science, Berkeley, CA

<u>Informal Classroom Research.</u> What do individual students expect for themselves in the future? Girls feel, in general, that women are competent with computers, but they, as individuals, are not (Chen, 1988; Collis, 1986). To assess attitudes toward computers by individual students, EQTEC educators ask students to write essays explaining how they will use their computers at age thirty. Analysis of the answers provides great insight into student expectations. Although neither sex makes much mention of computers in the workplace, boys expect to use computers for games and finances, while girls want computers to give

them money and do the housework (Kreinberg and Stage, 1983).

When high school computer courses are optional, who takes them? Boys take advanced programing and machine language; girls take data processing (California Department of Education, 1984). Students taking advanced placement examinations in computer science are 85 percent male, and their scores are considerably higher (3.07 to 2.36) than those of girls who take the exams (The College Entrance Examinations Board, 1985). Educators check these facts with their experience locally by actually counting the number of boys and girls in elective computer classes in their schools and districts. Informal classroom research has proved valuable in three ways. First, the results are usually surprising to the teacher-researcher, bringing increased awareness of students' attitudes and actions, and leading to increased commitment to effecting change. Second, the results are discussed with the students, giving them an opportunity to consider the implications of the finding. Third, the results can be combined with statewide or nationwide results to give a general picture to the local community of the problem at hand and to encourage efforts toward solution. Teachers have responded positively to the chance to do research related to their teaching (Kreinberg, 1980; Lortie, 1986).

Software Evaluation. Software evaluation for classroom use is an important and demanding task faced by conscientious curriculum developers. The teacher can make the computer a powerful tool for learning in almost any subject but the choices are many and difficult. Too often, advantaged white males are encouraged to use the computer for problem solving and programming, while females and some minorities are relegated to drill and practrice. Even the drill and practice activities frequently have "male" titles and feature violent payoffs for correct answers (e.g., on-screen "explosions"). In evaluating programs, educators need to screen for bias, violence, and excessively agressive competition. They need to choose programs that appeal to a wide variety of students, girls as well as boys, average students as well as high achievers, and to those motivated not only by graphics and music but to those who prefer science and mathematics as well. Utility programs such as spreadsheets, database management programs, and word-processing programs can become dynamic methods of content presentation. Consideration of all these issues, as well as the use of checklists that emphasize these points, help EQTEC participants sharpen their skills in the area of software review.

Logistics and Strategies for Equitable Computer Use. For several reasons, careful planning for full and equitable use of the available equipment will benefit girls more than boys, because (1) girls get fewer opportunities to use computers outside of school (Hess and Muira, 1985; Clark, 1986; Miura, 1986); (2) when computers are scarce, aggressive boys are likely to claim most of the time (Firken, 1984); and (3) girls are likely to self-select out of computing (Clarke, 1986). Awareness of these facts and plans for creating more opportunities for girls are addressed in EQTEC through discussion of logistics and strategies. In talking with teachers and administrators, we have found that nearly every school has a different policy on computer use and nearly every computer set-up is different, whether in terms of the amount and quality of hardware available or the location of the computers in relation to the classroom. Given a certain configuration, how can equitable computer access by assured? EQTEC participants identify the configurations with which they are most likely to be faced, e.g., one or a few computers in a classroom, computers in a media center, computers on portable carts, or computers in a lab. Participants examine suggestions for changes made by other educators, brainstorm additions to the list, try the strategies in classrooms, and revise in light of what they have learned.

Computers in Careers, Historical Landmarks, and Role Models. Computers in Careers and Historical Landmarks are activities that highlight the widespread use of computers in the workplace and the contributions of women such as Grace Hopper and Ada Lovelace to the history of computing. "Role models," i.e., women and minorities from industry and commerce, are invited to talk about their work and the use they make of computers. Participants discover the impact this makes and invite role models to their schools to speak with students. The speakers frequently mention the importance problem solving and cooperation have in their careers, and stress the opportunity to emphasize these learning modes with students. Typical comments are:

If I had to choose one overall skill that is essential in my work, it would be problem solving. I am constantly drawing on my knowledge and experience to solve new and unexpected problems.

--Engineer from Ford Aerospace and Communications

I wouldn't think of wasting my company's time trying to solve a problem by myself when I knew there was someone else in the company who could help me.

--Engineer from Bechtel Corporation

COMPTETENCE IN USING COMPUTERS IS ESSENTIAL FOR EDUCATORS

Competence in using computers as tools for problem-solving is essential in many ways:

*The competent teacher becomes a positive role model to students;

*Competence gives the instructor the courage to allow all students to take turns in moving and setting up equipment, trying out new programs, and solving problems. The teacher who feels uncertainty about fixing the equipment or debugging the program is likely to depend entirely upon the most knowledgable students -- usually majority males -- providing them with increased experience and denying any opportunity to those who could benefit most.

*Knowledge of the thinking and analytical skills essential to understanding computers enables the curriculum developer to design, modify, and use on-line and off-line computer activities to clarify difficult concepts. These activities are particularly needed by students who have not used computers extensively outside of school.

*The ability to use a variety of programs provides the opportunity to build an integrated curriculum that draws on subject matter from more than one discipline, thus appealing to wider student interests -- those of girls as well as boys.

Activities which EQTEC has found effective for building competence and confidence include "Limerick Machines," "Hardware Survival Skills," and plenty of hands-on microcomputer time. Analytical and thinking skills important for programming are addressed in "Robots," "Flipbooks," "Bubblesort," "Max Min," "Cooperative Logic," and certain LOGO activities that are chosen because they require problem solving, are interactive with other students as well as the computer, and transfer easily to other disciplines.

Limerick Machines and Hardware Survival Skills. Too often girls attribute "failure" to their own inadequacy (Fennema and Sherman, 1978), rather than recongizing the difficulty as an opportunity to "fix things" and learn. But working with a computer program has the potential for encouraging students in another direction. They can:

*(1) discover that things that don't work can be fixed;

*(2) look on the results of thinking as results that can be changed or fixed by erent thinking;

*(3) recognize that a mistake is not a macro-event essential to the process of solving a problem (Papert, 1980).

"Limerick Machines" is an off-line activity that can be used in the curriculum to develop diagnostic skills -- the ability to observe a difficulty, figure out what is going on, and reason out a way of fixing it, or perhaps declare it unfixable for specific reasons. Practice in fixing the "broken" "Limerick Machine" combined with fixing computer equipment and debugging LOGO programs provide insight into the skills of diagnosis.

"Flipbooks," "Robots," "Cooperative Logic," "Bubblesort," and "Max/Min." In using LOGO, participants practice making large procedures from small components. This is a powerful idea that can be used in many situations (Papert, 1980). The "Flipbooks" activity, creates the appearance of moving objects by drawing many small components only slightly different from one another, demonstrating that large procedures can be built up from small components. The activitiy can be used in the math curriculum during a discussion of motion; in the art curriculum for animation, the making of motion picutures and other moving graphic representations; and in the language arts curriculum by emphasizing the accompanying narrative. Wherever it is used, educators report that students of both sexes enjoy the experience and gain new understandings.

The LOGO language requires giving accurate, understandable instructions through the use of linear and angular measurement and a limited vocabulary. In preparation for using LOGO, EQTEC uses "Robots," an activity in which students work together to plan ways to direct a "human robot" to perform various tasks. They learn about instructions and conditions. Programming is limited by the machine being programmed, and the "Robots" activity can be extended to simulate complex problems being solved by complex machines.

Female students often respond more positively to cooperative approaches than to competitive ones, yet our schools stress competition, thus relying on a teaching technique that appeals primarily to boys (Gilligan, 1982; Shakeshaft, 1986). EQTEC uses many cooperative activities, among them, "Cooperative Logic", in which each of six people receives a slip of paper with part of the clues to a logic problem. Groups of four should omit the slips with astericks. The problem can be solved by talking about the information, using a pencil and paper or manipulatives, and reading the cards aloud, but the rules preclude showing the piece of paper to another member of the group. Each person must be responsible for her or his own part of the problem, and the solution cannot be obtained without the cooperation of all.

Two other cooperative activities, "Max/Min" and "Bubblesort," are based on algorithms a programmer might use to solve sorting problems. In "Bubblesort" a group of four or five people stand in line with the first person holding the control card. Only the person who had the control card at the time may move or cause others to move. Whenever a person gets the control card, she or he starts over. The instructions should be read aloud so the groups can understand what is happening and help out.

LOGO is our example language in EQTEC. It is easy to get into, can be used in a variety of ways, and is perhaps the most powerful and flexible language presently available for a microcomputer. Participants use LOGO to design an alphabet and to construct Spirolaterals, combining art, language, and mathematics in highly motivating lessons which can be used in a variety of ways within the school setting. It is not possible, or even desirable, to teach an in-depth LOGO course during a 30-hour computer equity workshop. However, participants are made aware of the resources, both print and course work, and may continue to develop their knowledge of the language.

EVALUATION

Participants evaluate the 30-hour inservice through a rating sheet for each activity, comment cards written at the end of each day, and a journal kept throughout the workshop. The ratings are generally high and the comments positive. Participants also keep journals throughout the academic year.

These journals reflect the struggles most went through to simply become familiar with the computer as a tool and develop confidence in their own skills. Some sample entries:

Things are coming together a bit. I no longer feel lost. Confused at times, but not lost.

Logo and recursion. I don't think I understand it well enough to teach it with meaning. The analogy to a family tree makes sense until I try to transfer the concept.

This computer business is a whole new ball game. You have a machine with an enormous potential. It can do just what you want it to do and it can do it very well, but it can screw up royally if you don't know what you are doing. The real shake-up is you can make mistakes the machine can forgive, and you can make mistakes you don't even know you've made, about which it is totally unforgiving. Part of the problem in teaching this to teachers is that we are conditioned to certain kinds of learning. There are rules we can learn and follow. There is a vocabulary that is common and which we know. That simply doesn't happen with computers.

One of the problems mentioned most often in the journals is the lack of time for curriculum development, the decisions concerning what to teach at a particular time and how best to teach it take time. The frequently expressed feelings of EQTEC participants echoes the statements of teachers in the Second National Survey of Instructional Uses of School Computers (Becker, 1985). When asked the most serious problem in computer use, "no time for the teacher to develop computer-based activities" was second only to the lack of equipment.

The participants' courage in trying new activities, modifying them, and trying again is remarkable.

I couldn't believe what happened when the students tried Cooperative Logic. They got really angry and totally out of hand. I was afraid there would be a fight right there in the classroom. When I called a halt to all this, no one had solved any of the problems. All week I thought about how to introduce it so they understood the point of working together and getting everyone *to understand rather than rushing through and trying to be first. I tried it again and this time everyone was much calmer and two groups actually finished.*

The EQTEC class and ideas have encouraged me to try new methods in my computer lab. I used to think every minute had to be spent on the computer since contact time was so limited, but many of the off-line activities have been valuable preparations that made the on-line time more valuable. The "Bubblesort" was a good way to show the students what was actually happening inside the computer program. The pre-LOGO activities really helped bridge the gap between the body and the abstract ideas the turtle [an on-screen feature of LOGO] is carrying out.

Nearly all journals included entries concerning equity and a renewed determination to ensure that girls as well as boys would benefit from the new technology.

I find myself encouraging girls to consider careers that deal with computers. When talking with kids I ask what experiences they have had with computers, I find some students doing homework with computers. Several girls have decided to take computer classes on weekends and during the summer.

I had a really neat experience the other day. It was Monday noon recess and the room with 17 computers was filled with GIRLS and several boys came by and said, "Oh, it must be girls' day." The girls are really using the computer lab just as much as the boys, at least at certain grade levels. Isn't that GREAT! Now I realize how important it is to really talk with the girls and tell them how important it is to learn to do lots of different kinds of things, and computers are one of those things.

Many participants wrote of the joy of learning something new.

My horizons have been expanded. I still don't know much, but I'm no longer intimidated by computers. Perhaps I know more than I *realize. People around me think I'm a "whiz" and come to me with questions (of all things!). I've been in charge of the computer lab for twelve weeks -- kids are enthused and have retained what I've exposed them to. Parents are awed by what their kids can do. I put on a parent workshop for 15 volunteers. Successful!*

Most often mentioned were the positive aspects of participant interaction.

It was inspiring to be part of a group of teachers who are still interested in learning and growing. Age seemed to make no difference -- the enthusiasm was great.

This workshop has been particularly varied in the level of experience that the different participants have. There are times when I have felt thankful to have been able to learn something from someone who knows more about computers than I do and other times when I have felt happy to have taught someone something.

I really believe the statement made earlier today that equity is for all students. The most important part of this program has been the meeting with other people and the sharing of ideas. Just the little helpful hints from others have often made a difference in my curriculum.

Schools are able to make changes when teachers are excited about their work and feel empowered to make those changes. Dan Lortie (1986) has written persuasively about the need for today's highly educated teaching force to have more autonomy, more sharing of practical experience, more opportunity to do research related to their own work. More than half of the participants in EQTEC chose to write for grants or to create workshops and inservice presentations for their own faculties. If teachers learn most from other teachers as research indicates (Kottkamp, Provenzo, and Cohn, 1986), then we must turn to teachers for help in redesigning our curriculum. Given time and a background of information and experience, teachers will develop curriculum that maximizes the computer experience for girls, develops girl's awareness of the need for computing skills, highlights the contributions of women to computing, and builds in opportunities for girls to learn through their strengths, persist when the going gets hard, and keep their options open for the new and demanding world they will face in the future.

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ON-LINE COMPUTER DATABASE IN SCHOOL LIBRARY MEDIA CENTERS FOR DEVELOPING SKILLS IN INFORMATION USE AND CRITICAL THINKING

by Carol C. Kuhlthau and Joyce C. Sherman

On-line computer database systems are being put to use in school library medical centers to develop skills in information use and critical thinking. It seems indisputable that we are on the threshold of the age of electronic information. Today's students will function as adults in a milieu where access to unlimited amounts of information from electronic sources will be commonplace, and the efficient and creative management of this information may well be the crucial ingredient to success. It therefore, becomes important for students to become familiar with this new means of accessing information as easily and quickly as possible, so they can move on to creative uses of the information.

Since January, 1985, Brunswick Acres School, a K-6 elementary school in South Brunswick Township, New Jersey, has been using Dow Jones News/Retrieval, an electronic information service. Dow Jones is an integrated service comprising more than 35 distinct databses. Among them: the full texts of *The Wall Street Journal* and *The Washington Post*; an electronic encyclopedia (updated quarterly), up-to-the-minute news and sports coverage, current weather information around the world, movie reviews (for films made in 1926 to the present), a college selection service, a medical and drug reference, the *Official Airline Guide*, book reviews, and an online shopping service. In addition, there are numerous financially related databases.

Brunswick Acres School was introduced to Dow Jones News/Retrieval as part of a pilot project involving four school districts in central New Jersey. The project was initiated by Dow Jones to determine whether, in addition to their already well established and successful financial market, there was an educational use for their service.

Two of the many questions explored by the pilot project were whether an elementary school was an educationally appropriate setting for an on-line database system and whether placing the system in the library media center would work. After 18 months of experience, no doubt remains and the South Brunswick Board of Education is sufficiently convinced of the value of electronic databases in the elementary setting to have funded their placement in all the elementary schools, as well as in the middle school and the high school library media centers.

On-line databases are becoming a basic resource in a library collection. They fill a void that has traditionally existed in libraries, particularly school libraries -- that is, the lack of truly current information. The very nature of printing means that much material is already out of date when it reaches the shelves. News/Retrieval makes available vast amounts of material that is either difficult or impossible to locate in other sources. The entire school population can have access to the resource when it is placed in the library media center. The cost of electronic databases currently limits the number which can be made available to students, and therefore, they are best used when placed in a central location available at all times to all students.

There are many databases from which to choose. Dow Jones News/Retrieval is only one of several electronic systems currently on the market. Dialog, Compuserv, and The Source are examples of others. The Dow Jones database has been found to be particularly appropriate for school library media centers because the information is relevant to many areas of the elementary and secondary curriculum. The information available can be readily applied to classroom learning and does not waste time with inconsequential, distracting material. Also, many systems charge for their service on the basis of time on-line, making cost predictions difficult for a school system. One of the advantages of News/Retrieval is a flat-rate charge -- per password, per year -- making it possible for a school system to budget accurately.

It is not necessary to be computer-literate to use Dow Jones/News Retrieval successfully. Students do have to know how to type on the keyboard. They quickly learn everything else through prompts from the machine itself. Brunswick Acres second graders studying Alaska daily checked the temperatures of Alaskan cities on the terminal and used the information to construct a weather graph.

The electronic database has proved to be a great motivator. Children who might be reluctant to use print resources will enthusiastically use the computer for sustained learning. The experience at Brunswick Acres has shown that the currency and relevance of information on News/Retrieval is highly motivating to students of all ages and all ability levels. Using an electronic source of information, even the most reluctant learners seem to experience a sense of mastery, leading to a greater participation in the management of their own learning.

In considering the needs of the learner and the educational goals of the teacher, two major learning objectives were identified. One was to develop skill and confidence using electronic information; the other was to develop the critical thinking skills needed in handling information.

The system has proved effective for developing skill in using electronic information. Children using the system become comfortable with the tehcnology and confident in their ability to access information. They learn the kind of information that is available and become aware of how they can meet their own information needs through the use of on-line databases. Through experience and practice, they become aware of the computer database as a tool for learning and decisionmaking. Literacy goes beyond reading to the ability to access and use information. Information use involves not only locating but analyzing, summarizing, paraphrasing, synthesizing, and presenting to others.

Critical thinking skills have been enhanced through using the on-line retrieval system. Critical analysis of information involves an understanding of opinion and bias. Children learn to make comparisons between different approaches to an issue. They become aware of editorial judgements made in the inclusion and exclusion of news items. They also develop skills in problem solving and making decisions based on the information retrieved in their investigations. Criticial thinking skills and information-use skills are developed naturally through activities which lead children to think critically about the information they locate.

Two kinds of activities using News/Retrieval were developed. Some were designed to be used by an individual student concurrently becomes familiar with the technology. For example, in "Racing to Win," a hypothetical one-mile race between a cheetah, a greyhound, Roger Bannister, the man who first ran a mile under four minutes, requires students to:

*(1) define terms such as win, place, and show;

*(2) obtain information from several sources;

*(3) compare meters and miles by converting numbers; and

*(4) solve time and distance problems.

Other activities were designed to extend and enrich curriculum-related topics. Access to current information breathed new life into some old classroom exercises. A biography unit, for example, no longer produced a classroom of students writing a thinly disguised, plagiarized report of an assigned figure from history. Instead, students work in an activity called "A Chapter in the Life of..." using current news stories to write biographical material about someone whose life is still unfolding in the pages of today's newspapers. As students gather information from primary sources, they gain a greater understanding of how biography differs from other forms of writing and expand their ability to evaluate the relative importance of factual information that might be included in a biography. How much more motivating it is for students to write a chapter in the life of Bruce Springsteen, Darryl Strawberry, or Mario Cuomo than the traditionally assigned subjects!

Studying explorers becomes an adventure when students use the *Official Airline Guide* and the *Academic American Encyclopedia* on-line, plus the standard reference sources and maps, to follow the travels of Christopher Columbus, or Lewis and Clark, for example, and then chart a modern airplane tour following the same route. Comparisons of elapsed travel time use mathematical skills and relevant geographical concepts are learned in a meaningful context.

In "The Rain in Spain," students use the weather and encyclopedia databases, as well as other resources, to collect and analyze information about the relationships between location and weather. Data about four cities located at similar latitudes are compiled and graphed. Variations are noted and hypotheses formulated about the relationship between temperature and location. Students are required to do additional research to draw conclusions and make comparisons about the data obtained.

The activity "Everyone's a Movie Critic" requires students to compare movie reviews in the on-line text to *The Wall Street Journal* and the movie review database, building an awareness of the difference between fact and opinion. The comparison activity is used as a springboard for a discussion of critical writing and is followed by the writing of individual movie reviews. The use of material that is current and of interest to students helps them develop an awareness that the source of material is an important factor in evaluating its validity.

News/Retrieval clearly enables the user to approach a topic from a variety of viewpoints. For example, a current environmental issue may be explored from governmental, legal, health, industry-wide, and specific corporate points of view -- all without leaving the terminal.

When a fifth grader became ill with chicken pox, it triggered concern in a fellow student. The stuent recalled that taking aspirin when one has the chicken pox could cause complications. The student tapped into MDEX, News/Retrieval's medical and drug reference and discovered the combination of aspirin and chicken pox could lead to the fatal Reyes Syndrome. Another student picked up on the business aspect of the aspirin/chicken pox combination to determine how the news affected stock prices of drug companies.

News/Retrieval is also being used extensively at South Brunswick High School. A chemistry teacher testifies that the teaching of periodic tables has been converted from one of the dullest exercises of the year to one of constant surprises. Students are assigned an element and told to find out all they can about it using News/Retrieval. One student, assigned the element flourine, found out that just a week earlier, a derivative of the element had been used in new ways to change the composition of racing car tires and in the process of making artificial blood. A student gaining this kind of information is likely to be motivated to a greater extent than a student reading about flourine's past application as described in an outdated textbook.

Using News/Retrieval, high school students have set up their own stock portfolios, recorded the daily price fluctuations of their investments over time, followed news articles about their stocks, and attempted to determine or infer what factors influenced their paper profit or loss.

Finally, there is an obvious excitement when it becomes possible to follow a fast-breaking news story as it happens. The old standby -- current events -- takes on new meaning. The News/Retrieval database provides information from the wire services with only a 90-second delay. The explosion of the Challenger and the incident at Chernobyl could be followed by students from moment to moment. Following the disaster in Bhopal, India, South Brunswick High School students investigated the Union Carbide chemical plant accident.

The use of the resource into school program has been most successful when initiated by the library media specialist. Inservice workshops for teachers to become familiar with the system have been conducted by the library media specialists. The most effective approach, however, has been for the library media specialist to initiate a project with a particular teacher with planning, teaching, and oversight being shared equally.

Teacher and library media specialists involved in the pilot project have compiled a manual of activities to be used in conjunction with News/Retrieval for primary grades through high school, based on their collective experience of what works with teachers and students.
The manual is available from Dow Jones as part of their service. These activities are merely a jumping-off point -- the ways News/Retrieval can implement and enrich the school curriculum are numerous.

In summary, an electronic database puts at students' fingertips vast amounts of current and historical information. The search for background and context is often transformed from a chore to an adventurous journey. Importantly, students spend less time locating and recording information and more time analyzing what they have found. The emphasis in planning teaching units can be placed on higher level thinking skills. Teachers can ask questions requiring more judgement, evaluation, and thought. Interrelationships, previously unnoticed, emerge between subjects under study and current political, economic, government, science, and environmental news. Finally, information delivered through telecommunications is hightly motivating to students. Today's world is truly brought into the school!

TECHNOLOGY APPLICATIONS IN BASIC SKILLS (TABS)

by Charles Mojkowski and Jean Sanders

A consensus is emerging among educational practitioners and researchers that new learning and information technologies should be integrated into the total school curriculum. That such common sense has yet to become common practice is testimony to the substantial difficulties of the integration effort. The technology, however, is not the central problem; instead, it is the curriculum, the organization of schools, and the allocation of resources that stand as the principal obstacles to appropriate and productive integration.

The Merrimack Education Center (MEC) has worked with scores of school districts, several intermediate service agencies, and State education agencies in eleven States on planning and implementing technology applications in education. From 1983 to 1986 the MEC staff worked on an in-depth development, implementation, and evaluation of technology applications in instruction. MEC and its school-based collaborators sought to examine the technology-as-tool approach as distinct from a computer-assisted-instruction (CAI) or programming approach. The primary research method employed was a case study design. One of three project components -- the use of word processing and writing at the eighth-grade level -- was evaluated, using a rigorous research design, but the findings from that relatively small component require replication in other settings and with larger populations before firm conclusions can be drawn.

PROJECT DESIGN AND IMPLEMENTATION

MEC's approach -- one gaining widespread acceptance among cutting-edge school districts -- is first to view the technology as a catalyst to rethink what is important for students to know and be able to do, and second, as a tool to help teachers and students to become more productive and efficient. In short, technology provides an opportunity to reexamine what should be taught and learned and <u>how</u> it should be taught and learned. The project had three phases addressed to this overall approach:

(1) curriculum transformation; (2) technology applications; and, (3) program implementation.

The purposes of the TABS project were first, to develop a comprehensive process for integrating technology into the curriculum; and, second, to develop replicable programs that use microcomputer technologies to enhance instruction in three basic skills areas: writing, scientific problem-solving, and learning/study skills. Our data collection and information analysis activities focused on the following questions:

* How can existing curricula be designed to accommodate and make maximum use of technology?

* How can the computer be used as a motivator and catalyst to revitalize existing curricula across all basic skill areas?

* What configuration of hardware and software is most appropriate to carry out instructional tasks?

* What instructional delivery systems and instructional strategies maximize use of the technology?

* What staff development and support models are most appropriate for local school implementation?

The TABS project was implemented in one middle school in each of three Massachusetts communities. Approximately 700 students and a dozen teachers in grades six, seven, and eight were involved in the project. The three districts varied considerably in size, resources, and previous use of new technologies.

The rationale for the TABS project is that the most appropriate and meaningful uses of technology are realized when technology is used as a tool to support a revitalized curriculum across all or most content areas. Appropriate and optimum uses of technology <u>require</u> a strong curriculum. To use even the best technology to deliver an outmoded curriculum will impede the achievement of our most important educational goals. Thus, the "appropriate" use of technology was defined in terms of the curriculum and student needs, not in terms of hardware and software. Only after the curriculum was refined did teachers turn to selecting and learning to use new technological tools. In addition, a heavy emphasis was placed on staff development so faculty could understand and practice the uses of technology. The final project component dealt with formal and informal assistance to teachers as they put new practices and activities to work in their classrooms. Implementation assistance included trouble-shooting, discussion groups, in-class demonstrations, and additional training.

In all three grades at each school, therefore, the major effort began with examining the basic skills curriculum to fully and appropriately exploit the unique capabilities of new technologies (e.g., microcomputers, videodisc, etc.). This curriculum revitalization stimulated extensive staff development for the teachers, including taking graduate level courses, to bring their technological skills up to a level sufficient to work with their students in this demonstration project. Based on training sessions conducted for the staff of each school, teachers prepared sets of lessons or instructional modules that integrated hardware and software with a corresponding area of the curriculum, across the different subject areas. To make teachers comfortable with these tool applications required teaching them highly complex skills that typically were not mere extensions of the capabilities they already had.

PROJECT ACCOMPLISHMENTS

Several general and specific accomplishments were documented through the case study and the research design for both the experimental and control groups. The case studies revealed that the schools were able to :

(1) prepare a setting and organizational structure conducive to change, including administrative support from central office;

(2) develop capabilities and expertise in technology, technical skills, and curriculum design;

(3) incorporate new role expectations for teachers;

(4) refine and verify the focused curriculum objectives so that technology could be applied in appropriate ways; and

(5) select qualitative and quantitative measures of student performance as part of an overall evaluation that included observation and performance testing.

School district staff not only selected technology software for use in the integration, but at the same time restructured their curriculum around appropriate, discipline-specific, procedural skills. This restructuring required added time -- an important step in the preparation of lessons as the curriculum were revised or modified for application of technology. The scope and sequence of the curriculum began to take on new dimensions, in an evolutionary sense, as the demonstration lessons and activities were created and used to determine how best to apply the software at each of the school sites. The project stimulated extensive curriculum revision in three skill areas. In each, greater emphasis was placed on procedural skills and knowledge within an integrated curriculum model.

Our judgement of the effectiveness of this project was based on several primary requirements:

* This project showed where appropriate techniques or methods were able to introduce efficiency and effectiveness into classroom instruction in three curriculum areas.

* Project staff identified successful ingredients for applications that could be adopted in more schools in the region, the State, or across the nation.

* Programs, curriculum packages and models were prepared and examples were identified in the implementation **Handbook.** Examples from a listing of teacher in-service modules demonstrated how to plan lessons for pupils using technology applications of word processing, data bases, spreadsheets or other software packages.

Teachers reported that the effects of computers on students were positive on motivation, subject interest, attention span, self-confidence, and cognitive learning. Project teachers noted that they were able to increase the variety of activities for students as a result of this microcomputer implementation. Teachers believed that the project increased their capacity to improve education for all students. Student attendance and motivation to learn improved substantially.

The writing/word processing component was evaluated with a pretest/post-test control group model, using one experimental and two control groups. The design was employed to assess the impact of the intervention (i.e., combined effects of word processing and a process approach to writing) compared to the most common program alternatives currently in use. Students in the experimental group were taught writing using the writing process approach combined with word processing. Students in the control group were taught writing using the writing process approach, but did not use word processing. The three teachers of the experimental classes also taught three of the control classes. Students in another control group, labeled external control, were taught writing using traditional language arts instruction by a teacher not participating in the in-service training or other phases of the project. The writing process approach alone produced a significant gain over the control group (effect size of .35); the combination of the writing process approach and word processing produced an effect size more than twice as large (1.19).

OBSERVATIONS

Small pilot efforts in each school allow for learning from our efforts and minimize the size and negative impact of the inevitable mistakes and false starts. Faced with stretching limited dollars across an ever-expanding collection of needs, most administrators believe they are fortunate to anticipate what needs and issues will arise next week. However, the rapidly burgeoning technology and its potential impact on all facets of schooling have served as catalysts for increased attention to planning. Careful planning focuses on the complexities that educators must address to make the best use of educational technology. Educational managers need to reconsider what truly are the basic skills for all students and the important, if not unique, role that schools can play in teaching students how to access, manipulate, and use knowledge, given the tools to today's technologies.

When fully implemented, technology yields benefits in educational effectiveness and school improvement efforts at three levels:

* Teachers and students develop new skills and competencies in using computers; students improve their basic skills in the areas of writing, problem solving, and research and study skills.

* All district staff have a model to use in developing a district-wide computer instruction program.

* The integration of computer technology in the total curriculum supports school improvement efforts in the area of basic skills across several subjects.

Based upon project accomplishments and on our work in planning technology applications generally, TABS gives rise to the following observations:

1. Technology is a stimulus to rethink what are truly the "basic" skills in education for the 1990s and into the 21st century. Basic skills now need to include learning to <u>use</u> the computer as a tool (e.g. accessing data bases, editing text on word processor, using telecommunications, and the like). Appropriate use of technology encourages a restructuring of the existing curriculum and provides a tool to help accomplish improvements that have been long desired in instructional settings.

2. Selection of software programs for the curriculum is difficult because of inappropriate matches. Time and resource constraints were repeatedly cited by interviewed teachers, and many of these were addressed as the project proceeded. Teachers require considerable support to prepare instructional units that incorporate technology applications. The time required to review curricula is often underestimated in schools trying to integrate interactive technology.

3. Some preliminary training for students on technical skills is essential. Schools should provide training in keyboarding and general technical skills before introducing more sophisticated tool applications.

4. In instances where there are limited computer stations, scheduling problems get in the way of a comprehensive program for the entire student body. Two of the three schools doubled their available equipment to overcome this constraint. In all three sites, advanced scheduling by the administration gave priority to meeting the needs of this project.

5. In the early phase of installation, computer use favors a laboratory setting, rather than classrooms, for several reasons. Not least are the demands placed on the classroom teacher to manage instruction. Instructional management and grouping modes have a great impact on both lab and classroom settings and on program success.

6. Content and process skills need to be defined and integrated into the curriculum. The operational definition of problem solving, for example, was selected using the OISE (Ontario Institute for Studies in Education) framework, especially the specific items on science attitude and scientific method. Generally, teachers who are already "process-oriented" tend to accept the process approach more readily and to proceed further in problem solving and other higher order skills.

7. Internal factors of structure and organization in the school have varying consequences on the diffusion of technologies in their different settings. Thus, the internal capability of the resource system in each school district contributed to the quality of the implementation effort.

8. Appropriate use of technology increases independence for students through grouping modes and activities that encourage peer sharing and attention to individual, independent assignments on advanced skills. This is more appropriate for the middle school or secondary school program where students develop advanced learning skills.

9. Technology tools, both hardware and software, should be simple enough for teachers or students to use without extensive technical skill and knowledge. Support for this technical back-up

should be provided (maintenance, minor repairs, optimum functioning of computer lab and equipment, etc.) as well as resource support.

IMPLICATIONS

In light of the literature on educational change, what conclusions relevant to other settings can be reached on these findings? We have found that technology can serve as a powerful lever to revitalize *what* we teach as well as *how* we teach it. We have found that often the simple technology tools that are available -- many without all the glamour of more complex software -- can be used effectively to help students extend their learning capacities and be more productive.

In studying and researching implementation issues, we have considered: (a) the technical cost and capacities (hardware and integrated software), and (b) the staffing and organization needed for successful integration within the curriculum of a typical middle school. Although the problems and issues confronted by the three sites overlap, they are not completely identical: their differences are reflected in the teacher interviews and profiles reported in doctoral studies by participants cited here.

Research has identified three categories of obstacles to implementing any program such as TABS; (1) the need to update knowledge or ability; (2) the need to find incentives for motivational dimensions, and (3) the capacity to allocate resources and adjust organizational patterns to accommodate the technologies. The introduction of new learning and information technologies suggests the need for new organizational structures in the schools, particularly in scheduling and grouping patterns. For the administrator who wants to have the most impact from limited resources early in the implementation, a microcomputer lab dedicated to word processing appears to be the application that should be tested first.

The implications of these findings and observations can be organized into program/curriculum revitalization and organizational development.

PROGRAM/CURRICULUM REVITALIZATION

1. Technologies are <u>means</u> of teaching, not <u>ends.</u> As prominent as these new machines may be presently, our goal should be to make them transparent in the curriculum.

2. The increased attention to teaching students how to use new learning technologies requires a comprehensive and deliberate instructional plan that is linked to all major subject areas in the school curriculum; this approach should help us reexamine the traditional subject and programming divisions of the curriculum in place. We will need to change <u>what</u> is taught as much as <u>how</u> it is taught. The new learning technologies can be used effectively to support a curriculum that is focused on procedural skills <u>and</u> knowledge (e.g., writing, learning, study skills, problem solving, etc.).

3. Given that large-scale curriculum revision may take several years, we have found that identifying targets of opportunity within the curriculum, as it is being revised, is a judicious approach to incorporating learning technologies. These targets are the curriculum areas or learning identified as priorities for more attention that can be supported by technologies.

4. An important learning from these activities is that the existing basic skills curriculum often is not appropriate nor configured to take maximum advantage of technology. One of our problems in education is that we are hoping for magic from the technology, hoping that our outmoded curriculum and instruction and our inadequate performance standards will somehow be changed by the introduction of computers and other forms of technology. If this is the case, what we will accomplish is change without reform.

<u>ORGANIZATIONAL DEVELOPMENT</u>

5. Much of our progress to date in using computers and related learning technologies has come from the efforts of individual teachers and administrators acting as innovators and entrepreneurs. It is important to use this base of innovative experience to develop

a district and school-wide framework -- one that incorporates both "top-down" and "bottom up" strategies.

6. Additional efficiencies in the application of technology can be achieved through multi-disciplinary approaches. For example, mathematics is the language of science; the computer is the "glue" to hold the two subjects together. The gains proved to exist when a laboratory approach (with tool applications) is used can be magnified by the power of the computer. Thus, substantial gains were realized for those students who participated in the process approach to writing with the microcomputer. Substantial gains were also realized for those students who received study skills and problem solving instruction within the science content area.

Profound changes, such as those envisioned for technology, imply reorganization of work, roles, and personnel structures. Being familiar with other major change efforts and participating in major staff development and technology implementation will provide some of the needed leverage to undertake this implementation process.

When studying change in school districts, technology innovations tend to be at the "difficult to adopt" end of the continuum. That is, they are usually not compatible with existing curriculum and mismatches occur. Also, schools' social systems are relatively complex and technology will require changes. Because of high, front-end capital investments, these technoligies may be high-risk in the sense that they are "less tryable" in a school setting. Certainly school boards are not going to invest more in hardware, software, and training without calling on teachers and administrators to show that computers have improved student performance. Schools are beginning to come to terms with these productivity tools, which have revolutionized business and industry and are now projected to revolutionize learning as well. We must now develop the tools to monitor this progress as a step toward increased educational productivity.

NOTES

1. Second Year Report. Technology Applications in Basic Skills. Funded

by the U.S. Department of Education, Secretary's discretionary grants, 1983-1986. Project descriptions available from Merrimack Education Center, 101 Mill Road, Chelmsford, MA 01824. This report is focused primarily on the outcomes of that project, but draws on all of MEC's technology applications work. In the first part of the report, we describe our overall approach to the tasks and issues associated with technology implmentation.

2. Two doctoral dissertations present the research findings and other insights obtained from the project, and discuss the implications of this new knowledge for program/curriculum revitalization. Data for the case studies and project documentation focused on the relationships and structure, as well as the capability of schools to perform with the new technologies and the transfer of technology into school settings. (Cf. Carol Eaton, Ed.D. Dissertation, Boston University, 1986.)

3. The findings of this project are significant considering the widespread use of computers in schools. A Computer Applications Planning Guidebook and the complementary **Handbook** for curriculum integration are available from Merrimack Education Center, 101 Mill Road, Chelmsford, MA01824

4. The Computer Opinion Survey was administered using a control group design, posttest only. This Survey showed positive results significantly in favor of the experimental group where students used the microcomputer demonstrating increased motivation and improved attitudes as a result of this experience. As expected, the differences attributable to gender were most significant on the Computer Opinion Survey. In the experimental group, the female students scored higher showing greater anxiety toward using computers. This was also true for females in the control groups. Despite the effect of gender, the experimental group still exhibited a signficantly more positive attitude toward computers.

TO SUPPORT THE LEARNER:

A COLLECTION OF ESSAYS ON THE

APPLICATIONS OF TECHNOLOGY IN EDUCATION.

How does technology support the disciplines?

Program Officer
Frank B. Withrow, Ph.D.
Team Leader
Technology Applications Group

Programs for the Improvement of Education

Office of Educational Research and Improvement
United States Department of Education
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SYNTHESIS:
TECHNOLOGY SUPPORTING THE DISCIPLINES

by Frank B. Withrow

All infants, whether they are gifted, handicapped, or average, begin to organize their cognitive world through their senses. The infant crying for food begins to quiet down at the sound of mother's voice or footsteps. Within the first year, most infants begin to understand some of our conventional oral/aural symbols. By year two, they are using expressive sumbols through speech. The reference to all of these symbolic structures comes from a knowledge based upon sensory experiences. The distant senses of vision and hearing tend to dominate, but who has not observed the infant who examines every new item by feeling, tasting, and smelling it? The near senses, however, are soon relegated to a minor role as the child becomes mobile and begins to use symbols. They rely more and more upon vision and hearing as the major information-gathering sensory senses. Certainly, we retain smell, taste, and touch, but they do not dominate our sensory experiences.

The often told story of Anne Sullivan's break through to the mind of Helen Keller through the use of running water demonstrates the association needed between real world sensory experiences and symbols.

Wendell Johnson asks us to remember that words and language are only the road map to the real world. True knowledge is based upon experiences and observations that are expressed publicly through symbolic form. Symbols may take many forms from speech, mathematics, writing, dance, music, art, and the newer codes of the electronic age. The sumbols allow us to organize our experiences in shorthand form. In turn, the symbols themselves let us organize our thoughts in new ways.

In a modern society, children are both immersed in the real world and separated from that world more than at any time in our history. In a simpler society, their role models were family, parents, and apprenticeships. In that sense, the youngster was an intricate part of the daily activities of the society. But today's society is much more complex. Children are kept from participating in the adult world for a longer period of time than they once were. But at the same time, the surrogate world of television reaches the child at an earlier age. By the time the child enters school, he or she will have a 4,000 to 6,000 word vocabulary and on the average will have watched 9,000 hours of television. Some children will have interacted with computers, and almost all will have used the telephone and listened to records. What does this mean for child growth and development? It is popular -- and easy -- to condemn the media as a "plug in drug" or as a reason for the "destruction of childhood." Some would like to turn the clock back, possibly to a time that never was. I prefer to ask what this means to child growth and development and to think in terms of developing critical skills for using technology. The world at large uses technology, and our children must learn to live with and use technology to our advantage as a society.

It is in this context of symbols, media, and technology that this chapter examines how television, computers, and other technologies impact upon the disciplines through which young people organize their cognitive skills. The basics of reading, mathematics, and writing provide a refinement of the use of symbols to organize learning experiences.

An example of the new technologies might be an article and discussions on the works of Scott Fitzgerald which, on a CD/I format, could include all of the background materials that were available when Fitzgerald lived. These could be a collection of the songs of the times in stereo sound, political speeches of his time, posters and illustrations of the time, and simple radio dramatizations of student bull sessions that influenced Fitzgerald. In fact, National Public Radio has developed an audio tape that encompasses these elements. It would be simple to transfer those materials to a combined print and audio format on CD/I. CD/I is an example of consumer-friendly laser computer technology.

Judah Schwartz discusses the need for teachers to constantly question even the most basic elements in education. He reminds us that mathematics is simply a symbol format for describing the real world, and warns against thinking that mechanical manipulation of numbers is an end in and of itself. The computer allows very young people to do complex mathematical manipulation of ideas, to describe very complex principles graphically, and to try various factors and to examine what happens, all at great speed. The computer also allows us to develop tools such as the ones developed by Schwartz that lets the student "suppose." Suppose I do a series of operations on a right triangle. Will they remain the same when the triangle is obtuse? Such tools allow the student hundreds of rapid manipulations. With help from a well-trained teacher, the computer provides a tool that leads the learner to generalizations of basic principles and to a better understanding of the complex symbol system we call mathematics.

Roy Unruh discusses the use of computers as measurement tools in physics. The simple, cheap laboratory tools that can be found with even the most inexpensive microcomputers provide temperature, light, sound, pressure, and other measurement devices that can be used by high school and elementary school children. The microcomputer has the added advantage of presenting the data in graphic formats. Temperature can be measured over time; sound voice prints can be captured and examined. Just as in mathematics, the computer allows the student to make literally hundreds and even thousands of measurements with relative ease. It is this new "tool use" of the computer that may bring real science experiments back into the realm of the average student's experience. Again, just as in reading and mathematics, television and computers offer the student tools for close examination of the real science used in the world today.

Tom DeRose and Martha Deming discuss the use of multi-media reading programs. They use a science fiction television series, "Storyland," to establish various reading skills. These are followed up with microcomputer programs that allow the student to practice the skills learned through the television programs. The themes of the television series appeal to the upper elementary child's sense of values. There is the evil leader determined to keep people from reading. The good guys, the "Storylords", rush into the story in the nick of time to help the people save the day by understanding critical reading elements. The great burden of the Storylords is passed on to a young boy in Wisconsin who lives up to his new responsibilities as the old Storylord passes on to his just rewards. As well as developing skills, the series establishes values that support reading.

Andee Rubin discusses the need for social meaning in her use of the computer for developing writing skills. Youngsters, like adults, will write if there is a meaningful result. Writing simply as an exercise is not appealing to either adults or children. But writing as Rubin describes it becomes an extension of our basic communication system, a way to share our personal experiences and needs. The example of the teen-aged girls in Alaska describing the lack of suitable teen-aged boys in their small village is a prime example of functional writing. Perhaps not scholarly, but certainly meaningful to the young ladies.

Henry Olds has described word processing as "idea processing." I like that concept because it correctly shows that the word processor is much more than a new quill pen or typewriter. As Rubin describes in her paper, the use of computers in expressing ideas through writing gives the student and teacher exciting new tools, which should not be limited to the English class, but which should become a vehicle for students to express their ideas in science, technology, social studies, and all subjects.

Perhaps the most interesting paper in this chapter is by Ben Thomas, a classroom teacher on sabbatical, who explored the uses of the computer in the humanities. Just as in the other areas, Thomas found that the use of a computer to create poetry, to allow students to write, and to explore literature is yet another tool. There is a videodisc/computer program on Shakespeare's work. It allows the student to explore different stage sets that have been used by different producers. It also has a data base of different interpretations of plays that run from traditional to modern settings and interpretations. In effect, the student can read a scene and then examine different stage settings and different renderings of the play. In addition, there is a utility tool that allows the student to create his or her own stage settings by using computer graphics.

Throughout this chapter, the authors have expressed the new utility of the technology that allows students and teachers to examine the real world differently, to evaluate those observations, and finally to express their own observations and ideas in new ways.

I see these new technologies as extensions of our traditional symbol systems. It is important to remember that the printing press is only 500 years old, the telephone 100, broadcast radio on a national basis less than 65 years, television 35 years, satellite communications a decade, and microcomputers less than a decade. We know a lot about these technologies, but I doubt that we have developed the full force of their potentials for education. They may define traditional disciplines in new ways. The power of their ability to store information and to present it in different formats may change our understanding of the learning and teaching processes.

It would be tragic if the educational community failed to understand the full implications of technology on the learning process. Just as the book forever changed the relation between the teacher and student, electronic information systems will transform the way we educate ourselves.

THOUGHTS ON SOME OLD PROBLEMS AND SOME NEW TOOLS

by Judah L. Schwartz

TWO PRINCIPLES

In this paper I would like to raise several issues that seemingly have nothing to do with technology but illustrate my belief that technology can profoundly transform what we and our students do. I begin with two arithmetic problems:

> Sarah has three bags of candy. In each bag there are five candies. How many candies does Sarah have altogether?
>
> Esther has three skirts and five blouses. How many different outfits can Esther make?

You will notice that each of the problems requires the student to multiply the number 3 by the number 5 to get an answer of 15. It is the case, however, that the first problem is thought to be relatively simple by the vast majority of fourth and fifth graders, while the second problem presents most of the same group of youngsters with serious difficulty. Why is this, given the fact that the required arithmetic is the same in both cases?

The reason that we as a society insist on arithmetic in particular and mathematics in general as part of the curriculum is that they provide us with a set of tools to analyze the world around us. The numbers we use in that analysis all refer to something. In the problems we began with the quantities we used were:

5 candies per bag

3 bags

5 blouses

3 skirts

It seems to be the case that multiplying 5 candies per bag by 3 bags is easier than multiplying 5 blouses by 3 skirts. Since the difference in difficulty cannot lie in the numbers, somehow it must reside in what the numbers refer to.

This is not the place to sort the issue out in its entirety. Suffice it to say that the quantity that refers to candies per bag is different in kind from the others. We all know that more or less intuitively. In order not to bog down in our nascent mathematical careers, we have to come to have a much deeper and formal understanding of such "per" quantities.

The reason I raise the issue of "per" quantities is to illustrate the fact that the arithmetic we ask even the youngest of our children to learn is subtle. It is sufficiently subtle that it is hard for me to imagine anyone coming to feel that he or she understands all the grade school arithmetic there is to learn so well that there is nothing more to learn.

Unfortunately, many teachers do not view the teaching of mathematics this way. All too many of them are willing to teach in a way that gives the appearance of their knowing all there is to know about the subject, without a hint of their continuing struggles to understand its subtlety and nuance.

This brings me to a statement of two principles that I believe are absolutely necessary to improve mathematics teaching in our nation's schools. They are:

> It is important to recognize that the mathematics we teach little kids is subtle.

From this it follows that:

> The people who teach little kids mathematics should regard themselves, and should actually be, lifelong learners of the mathematics they teach.

As we shall see later, these principles will lead us to consider a special role for microcomputer technology in the future education of our people.

KNOWING SOMETHING IN MORE THAN ONE WAY

I once had a friend who told me that he wasn't ready to teach a particular subject yet, because, as he put it, "I don't know it enough different ways yet".

We approach knowledge differently, and we often build quite different internal models of what we are learning or are being taught. If teachers are to make contact with youngsters who represent the subject differently, then they will be better prepared to do so if they have a rich repertoire of ways of representing what they are trying to teach.

If readers are prepared to take my two principles seriously, then this point will not surprise them. Subject matter is subtle precisely because it is possible to represent concepts to oneself in different ways.

This is not an issue that was raised by technology; it has been a problem of good pedagogy from time immemorial. But, as we shall see later, the microcomputer offers some quite special opportunities to learn and teach better.

LEARNING THE OLD AND MAKING THE NEW

I would like to raise another issue about the learning and teaching of mathematics that, on its face, has nothing to do with technology. If we taught English the way we teach mathematics, we would ask youngsters to learn a novel by Dickens, a play by Shakespeare, a short story by Hemingway and a sonnet by Donne, but we would not ever ask them to write a piece of prose of their own.

Why is it that when we teach mathematics we are willing to ask youngsters simply to learn the mathematics other people have already made, and never make any of their own? What would it mean to ask youngsters to make mathematics? In my view, it would mean asking them to explore what hitherto unknown relationships might hold among the mathematical objects of their interest. But what, you say, is a mathematical object? Mathematical objects are such things as integers, fractions, circles, triangles, quadratic forms, functions, sets, groups, graphs, etc, etc.

On this point as well, I will argue later that there are special opportunities presented by the microcomputer.

THINKING ABOUT ONE'S OWN THINKING

Clearly we want our youngsters to grow up to be individuals who reflect on what they are learning. But, I believe we also want something more. We want them to reflect on the nature and quality of their own reflection. What better way to attain that goal than to give them practice with these two levels of reflection in school and have them be exposed to reflective teachers who reflect on what thev themselves are learning. This too, is not something new to education. Does technology have something new to contribute?

THOUGHTFUL SOFTWARE THOUGHTFULLY USED

I would not have raised each of these issues if I did not believe that thoughtfully designed microcomputer software used in thoughtful ways by thoughtful teachers could make a profound difference in the quality of education.

Let me be specific. I will draw my examples from mathematics software developed at the Center for Learning Technology of the Education Development Center (EDC) in Newton, MA. and the Educational Technology Center (ETC) at the Harvard Graduate School of Education.

The Semantic Calculator (SemCalc) developed at EDC is a tool that allows people (of any age) to calculate, not only with the numerical values of the quantities they calculate with, (the 5 in 5 candies per bag), but also with the referents (the candies per bag in 5 candies per bag). In such a software environment, our two opening arithmetic problems are clearly different and the user quickly comes to appreciate and internalize the difference. Lest you think that SemCalc is somehow limited in its application to fourth of fifth grade arithmetic word prolems, let me assure you that it is equally useful in high school chemistry, college physics, accounting, running a business, or any other domain in which the quantities we use refer to something.

In SemCalc the computer is not doing anything sophisticated, nor does it ever make any judgements as to the correctness or incorrectness of the computation you ask it to perform. It is, in that sense, precisely like your ordinary calculator. It simply shows you what consequences your actions entail; it is for you to decide whether those results are the ones you need in the situation at hand.

The software being developed by the word problems research group at ETC deals with the difficulties many students have with understanding ratios. It uses three different representations of ratio; one iconic, one tabular and one graphical. The software provides an environment in which a student can explore in the representation that he or she finds most congenial. Whatever moves the student makes in any one of the representations are immediately reflected in the other representations. Perhaps, in this way, it will become possible for youngsters to come to understand ratio in "enough" different ways so as to feel comfortable with the concept.

But there is a more general point here. Wherever there is a domain in which a variety of possible representations can be mapped onto one another, one can use the computer to present all the represetations simultaneously. The simultaneity allows the student to explore the correspondence between the representations by moving in any one representation and examining the consequences of the move in all the others. In classical educational psychology this is called "transfer."

The "Geometric Supposer" software series developed at EDC provides a software environment in which both students and teachers can study already known geometry as well as discover new geometry. The software has been widely used with great success with a wide range of students, both in age and in the usual measures of ability. Perhaps the most gratifying result of this use of the technology is its success in transforming the perception of mathematics from the study of a dry and dull subject whose boundaries are already known and well explored to a subject that is alive and in a state of constant flux, not unlike music and art.

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SCIENCE IS PROBLEM SOLVING

by Roy Unruh

To participate in science is to engage in problem solving. To a scientist problem solving means becoming intellectually interested in phenomena, making observations, developing relationships, and creating models. These relationships and models are then used to predict events and make further observations. These further observations are in turn used either to confirm the model, or if they do not support the original model, to modify it or create an alternative.

Science educators try to develop materials and teaching strategies that not only help students understand basic concepts in science, but also communicate the nature of science. Students develop an appreciation of science when they can find relationships and create interpretations of events that explain their observations.

ROLE OF THE SCIENCE LABORATORY

The science laboratory is the most fertile arena for engaging in the process of science and for relating concepts related to concrete experiences. Examples of problem solving skills include observing, inferring, measuring, communicating, predicting, graphing, drawing conclusions, controlling variables, hypothesizing, defining operationally, experimenting, and formulating models. Some additional laboratory skills are associated with formal reasoning processes such as proportional reasoning, combinatorial logic, and hypothetical deductive reasoning. Strategies have been proposed in such materials as *Science Teaching and the Development of Reasoning* (Karplus, 1977), supported by the National Science Foundation, to cultivate reasoning skills.

Many teachers find that it takes considerable effort to take advantage of the laboratory as a vehicle to develop thinking skills, an effort that requires reevaluating teaching styles. The focus in most commercial laboratory guides is on verifying concepts that are taught in the text, which do not give the student the freedom to cultivate their own problem-solving skills. Teachers often feel a need to cover a large number of topics; consequently, they don't feel they have the time to provide the students with experiences in which they explore some of the relationships.

LABORATORY SIMULATIONS

Students of science need to have learning experiences that engage them in making decisions that cultivate the skills that go with scientific investigation. Some computer programs take advantage of the fact that experiments can be simulated that could not otherwise be conducted. The IBM Physics Discovery Series contains such simulations as investigating the variables that affect the gravitational force on the cabin of a spacecraft, investigating variables that affect the potential and kinetic energy of a roller coaster at an amusement park, and others which use settings too difficult to reproduce in a laboratory or settings which relate physics to high-interest phenomena. These programs have educational objectives which include:

* exploring and developing possible interpretations of physical phenomena;

* developing reasoning and problem-solving skills;

* designing experiments to determine how a dependent variable is affected by independent variables; and

* developing scientific models to explain observations.

In the program, **Investigating Gravitational Force,** the student has command of a spacecraft that has "sensors" which can detect the mass, distance, and density of planets, as well as the gravitational force between the planet and the spacecraft. The student can alter the values of any of the independent variables and then press the "enter" key to see how the gravitational force responds. As this process continues, the student is encouraged to look for patterns or relationships between the gravitational force and the independent variables.

The question of interest is: "Can students be provided with the same mental encounters in a laboratory simulation program as in the actual laboratory?" In an effort to gain insight to this question, Hrecz (1985) compared how students controlled variables in **Investigating Gravitational Force** with how they scored on controlling variables with the bending rods Piagetian interview task. The interviewer rated students on the basis of the number of variables that were changed in the computer simulation and the verbal responses students made to questions from the interviewer. The bending rods task was chosen because of the existence of a standardized protocol and scoring technique for controlling variables with laboratory apparatus. There was a .78 correlation between student performance of controlling variables with the laboratory simulation program and with the laboratory interview task.

This result suggests that the mental encounters of a student controlling variables with actual laboratory apparatus is highly correlated with the mental process occurring at a computer keyboard for the program used in the study. This suggests in turn that laboratory simulation programs can be written to engage the students in higher level reasoning skills. While many science educators would feel there is no substitute for hands-on laboratory activities, there could be several advantages to the simulation programs. Students can become engaged in the program without teacher supervision. Types of events can be simulated that have a greater student appeal than events that can be simulated in a school laboratory. Questions can be carefully formulated by experts to create the proper background and environment to help students use reasoning skills. And, students receive immediate responses to their actions and can learn from their mistakes.

Some programs are designed to simulate alterative models for describing certain physical events. Educational Materials and Equipment Corportation (EME) has a program, **Laws of Motion,** which simulates a block sliding down an incline plane. Besides being able to change variables such as the angle of the incline, the mass of the block, and the friction between the block and plane, the students may select either the Newtonian or the Aristotelian view of falling objects. In either system, the motion of the block may be viewed with graphic comparisons made of the displacement and velocity vs. time. Students require such thinking skills as exploring, observing, controlling variables, analyzing data, and evaluating models to successfully complete the task.

THE NATURE OF COMPUTER INTERFACING

Laboratory probes may be inexpensively linked to a computer by way of game ports, printer ports, or circuit cards. These probes can be used to measure temperature, light intensity, force, heat rate, breathing rate, distance, velocity, and sound. The measurement of these variables can be displayed on the screen in real time as the data is being collected and plotted against time on a graph. This allows the students to see the graphs being generated at the same time as the measurements are being taken in the event. This instant display of the graph allows the student to explore the effect of changing a variable and immediately noting the result.

Since the probes are under the control of the student, the student is much more likely to see the connection between the measurements from an experiment and the graph of the data with appropriate interpretations. All of this can be accomplished without the drudgery and time consuming effort of plotting data points before conclusions can be reached. With such a large investment of time in collecting and graphing data, students lose interest in exploring the effect of other variables and feel they are penalized for their curiosity. With these probes students can spend more time during the class period in encountering and cultivating problem-solving skills.

One of the most common probes is a temperature probe. The software typically allows the student to either display the numerical values of the temperature or to plot temperatures taken at selected time intervals. Students may explore the concepts of heat and temperature, which are frequently misunderstood, by comparing the effect of adding a small amount of hot water with adding a larger amount of warm water to a given container of water. As the probes are placed in different evnironments, students will note the changes in temperature from the graphs as well as the rates at which the temperatures change by observing the slopes of the graphs. Students may be given a graph of changing temperature and be asked to change the temperature of the probe to match the given temperature graph. These experiences are excellent for relating events with graphical representation and interpretation of data.

Students may take advantage of multiple temperature probes in experiments involving the performance of cardboard box greenhouses, a second one may be used to monitor the temperature of water in cans used for heat storage inside the greenhouse, while another probe is used to record the outside temperature. This experiment could run for 24 hours with the data recorded on a disk, then be displayed for analysis during another class period. The effect of energy placed in storage could be shown on the night-time temperatures. Several variables could be changed, including the size of the collecting surface, the volume of the greenhouse, and the amount of water used for storage. This experiment demonstrates another useful aspect of the computer, namely that it can be used to collect data over long periods of time without the presence of the experimenter.

MOTION DETECTOR

A motion detector was developed by the Technical Education Research Center (TERC) (Barclay, 1986) from a sonic transducer used in Polaroid cameras. The motion probe sends out short pulses of high frequency sound and then measures the time required for the echo to return to the unit With this information the program will calculate and display in the form of a graph the position, velocity, and acceleration of an object between .5 meters to 8 meters from the probe. The data and any of the graphs may be displayed at the same time as the motion is monitored. Various types of motion may be investigated, including the motion of individual students, toys, a pendulum, and a falling body. Data can then be analyzed, transformed, printed, and saved onto disks.

From a position vs. time graph of the the motion of individual students, questions can be asked of students to direct their understanding of displacement, velocity, and acceleration. They may be asked where on the position vs. time graph they turned around and approached the transducer, if they ever moved with constant velocity, where they moved the fastest, what their speed was at a particular time, and so on. After students have been shown either a position vs. time graph or a speed vs. time graph, they can move so as to be able to duplicate the graph.

This motion detector has been used with different students, ranging from sixth graders to humanities students taking physics at the college level. In both groups, motion was introduced by observing graphs created by the movement of their own bodies. The sixth graders showed by their class discussions and test results that they developed a sophisticated understanding of motion and of position and velocity graphs. The college humanities students also showed excellect achievement, nearly equaling the performance on similar test questions as freshman physics majors.

MEASUREMENTS OF HUMAN BODY FUNCTIONS

To make measurements and conduct experiments involving the human body provides strong motivation and interest for most students. Light sensitive probes have been used by several manufactures to measure the change in light transmission through thin layers of skin caused by variations of blood flow or pulse rate. Pulses of several class members can be measured and differences and similarities noted. Hypotheses which may account for these differences, as well as what may cause a change in the pulse rate of individual students, can be generated. Variables such as amount of exercise before a reading, physical conditioning, and the effect of caffeine can all be tested on a classroom of students.

SUMMARY

The educational community has placed increasing emphasis on developing thinking and reasoning skills in this decade. The National Science Board has stressed the importance of learning skills in observing, classifying, communicating, measuring, hypothesizing, inferring, designing investigations and experiments, collecting data, drawing conclusions, and making generalizations. Acquiring these thinking and problem-solving skills can surely be enhanced by using the computer in high-quality laboratory simulations and through the use of software that allows students to associate the unfolding of a graph with the transpiring of an event.

COMPUTERS AND WRITING: THE INEVITABLE SOCIAL CONTEXT

by Andee Rubin

What would you do if you were a 14-year old girl living in a tiny, inaccessible rural village and you felt your world was uncomfortably limited? What if, to make matters worse, you didn't like a single one of the available boys? Some of the solutions that come to mind involve written language: reading about other places and people to expand your knowledge about the rest of the world; trying to find a male pen pal to establish contact with some other (hopefully more suitable) young man. Several teenage girls in McGrath, Alaska, a town of 500, took exactly this approach. Presented with the opportunity of using an electronic mail system, they composed the following "open letter" to potential suitors.

"Calling all men"

Hi,

This note is to all you good-looking guys out there in the world. There are two of us writing so we'll tell you a little bit about ourselves. Our names are Sally Foster and Terry James. We're both 14 and stuck in a small town in Alaska called McGrath. We have a pretty big problem and we hope that you guys will help us out. We have a very short supply of foxy dudes here. So if you are a total fine babe PLEASE write us!!!

Write: (their address) and hurry!

Keywords: McGrath, Male Order Men

Not to be outdone, two girls in Holy Cross, an even smaller town, composed the following message. They tried hard to outshine their rivals and be even more attractive to the boys. In particular, they targeted their audience by addressing their message to "Juneau boys." They also spent a long and fairly tedious half-hour mastering the intricacies of the word processor in order to produce the heart at the end of their note.

"GOOD LOOKING JUNEAU BOYS"

Our names are Joyce Peters and Elaine Towson. We like skiing, basketball, hockey, writing letters to cute boys, and we would be more than pleased if any of you cute boys would write to us. We don't have any boyfriends. So you don't have to worry about that! We also would like you to send a picture when you write. (You are going to write aren't you?) We will send you a picture, too. Joyce is 14, and Elaine is 13. Well, please write soon! We are waiting for your letters!!!

Keywords: Juneau Boys. Holy Cross Girls

These two examples illustrate one intimate connection between social interaction and writing: the social environment as a source of purpose and audience for written communication. Without a reason to communicate, these students would not have written as they did; without their perception of the importance of that reason, they would not have persevered in their exploration of the word processor. The embedding of the writing task in a social context created a powerful educational opportunity for these students.

The common vision of educational software stands in stark contrast to this scenario: students working alone at individual terminals, receiving much of their evaluation and feedback from the computer, working on a series of tasks determined by the machine. Originally this interaction took the form of frame-based, computer-assisted instruction, in which the computer posed and judged the answers to multiple-choice questions and proceeded based on their correctness. As research on educational technology has grown, the contribution of the machine has become more sophisticated. The modern extension of CAI is the notion that the computer contains an expert model of the subject area, plus strategies for passing on that expertise to a student. This general Intelligent Computer-Assisted Instruction (ICAI) model envisions a series of subject matter specific systems that can interact with individual students, monitoring their understanding of the subject, presenting appropriate examples and problems, and choosing effective pedagogical approaches for the current situation. Systems in subjects such as geometry (Anderson), algebra (Sleeman), arithmetic (Brown and Burton), programming (Soloway, Anderson), medicine (Clancey), and electronics (White and Fredericksen) have been moderately successful in teaching students about their chosen topics.

What can we make of this contrast between mail systems that students use to communicate and ICAI systems that tutor students in particular fields? Is it possible to develop a successful ICAI system in writing? A quick glance at the list of systems above reveals at least a surface similarity in the domains reseracher have chosen to explore: They are drawn primarily from the field of mathematics and science. Is this merely coincidence or is there a fundamental difference between these domains and those conspicuously missing from the list? In fact, it appears that certain domains are eminently more appropriate for ICAI systems than others, and that there is a large class of subjects for which an entirely different approach is more feasible and effective. This article argues that writing, because it is inevitably embedded in a social context, is not an appropriate domain for systems in which the computer is the main source of expertise. It goes on to describe a different approach to educational technology, embodied in a particular piece of software, that unites software and the social environment into a potentially powerful educational environment.

WHERE IS THE EXPERTISE?

Arithmetic (adding, subtracting, multiplying and dividing) and writing provide a good contrast of domains in which the computer can act as a tutor. A first prerequisite for a tutor is knowledge of the subject matter itself. As stated most straightforwardly by O'Shea and Self (1985), "computer tutors should know what they teach." This can be interpreted as a requirement that the computer be able to actually perform the task the student is learning to master. In arithmetic, this is clearly the case; a system can certainly be written to calculate the answer to arithmetic problems. But, while a computer could certainly be programmed to write any particular story, essay or poem, it is impossible (at this point) to write one that could respond to the variety of writing assignments that students need to handle, from "What did you do on your summer vacation?" to "Who was the true hero of Julius Caesar?"

Closely related to the ability of the machine to perform the educational task is its ability to evaulate the student's response. Again, the contrast between arithmetic and composition is notable. In arithmetic, an answer is generally either correct or incorrect; people have little difficulty agreeing on their assessment and computers, as well, can evaluate these answers easily. In writing, however, evaluation is highly subjective. Even human raters spend significant time and effort trying to correlate their assessments, particularly in standardized testing situations. While a sophisticated piece of software (e.g. "Writer's Workbench") can evaluate and even correct a student's grammar and usage, research in computerized language understanding is nowhere near the point where a computer could understand or evaluate a large selection of texts. In the absence of computer evaluation, of course, we need to return to evaluation by people -- both teachers and peers.

A prerequisite for truly intelligent tutoring systems -- those that analyze how the student is solving problems and identify the student's mistakes, or "bugs" -- is that the problem-solving process be representable in some formal way in the system, so that it can identify and simulate a student's erroneous behavior. In the most well-known example of a system that points out students' consistent bugs, DBUGGY scrutinizes a student's answers to a set of addition problems and discovers such patterns as "the student always adds all the digits together, ignoring place value." (Such a student would, for example, think 23+32=10.) Such a diagnostic approach is not possible in writing, except in the limited area of mechanics. It is hard to imagine a program that would say to a student, "Your topic sentences are often difficult to distinguish." or "Your tone in general is too condescending." Yet some sort of informed diagnosis and subsequent assistance is central to the notion of intelligent tutoring systems. Again, writing seems like an inappropriate choice of domain.

Finally, consider the role of "background knowledge" -- the general knowledge the student brings to the task -- in arithmetic and writing. In arithmetic, most of what the student knows is not related to the task at hand; knowledge about sports, cooking, or American history is not immediately necessary for doing arithmetic. Such knowledge, on the other hand, is intimately connected with writing. It is, to be precise, the content of what students compose. This connection makes the construction of software to teach writing even more difficult, for a useful program would have to know many facts about the world in order to judge the coherence and organization of a student's composition.

It appears, then, that the ICAI approach will run into trouble in the field of composition. The "expertise" about writing that students need to encounter and adopt can not be contained solely in the machine. Rather, the computer's capabilities and the social environment -- teacher and peers, both near and distant -- must interact to create a situation in which students can learn to write more effectively.

COMPUTERS AS COGNITIVE AND SOCIAL TOOLS

What is the computer's unique contribution to this synergy? First and most frequently mentioned is the computer's role as a tool. Word processors reduce the pain of editing and revision, allow students to format their work, produce profesional-looking copies of text, and make it easier for students to read their own and others' pieces by eliminating problems of illegibility. Spelling checkers help students make their final drafts more readable and on-line thesauruses provide resources for students searching for more precise words. Recently, schools have also begun to use outline processors, programs that let students compose and manipulate an outline before or during writing. In the future, there will undoubtedly be more sophisticated writing tools: on-line dictionaries, multimedia dictionaries, and grammar checkers. These tools all help with the cognitive aspect of writing.

Of course, there is a social context surrounding any activity in school and using computers for writing is no exception. The assignment the teacher has given to the class, the physical space in which the students work, the amount of time they spend talking to one another and the teacher about their piece, the choice of audience, and the purpose students have for writing all influence how writing tools are used and what students learn. But it turns out that computers, along with being writing tools, can themselves create and modify social environments. This is especially true in a subject such as writing, in which the social environment is so central to the learning process and the subject matter; here, the effect of software on social interactions needs to be carefully considered and investigated.

Quill (designed by Bolt Beranek and Newman Inc. and the NETWORK Inc., under contract from the Department of Education) is a system designed to facilitate students' learning to write. It includes both writing tools and writing environments; that is, it attempts to change both the cognitive and social environment in which students write. Interestingly, classroom experiences with *Quill* also demonstrated that the social environment in the classroom changed in ways the developers had never anticipated. In fact, the complexity of the interaction among software, curriculum, teacher, students, and administration was one of the significant aspects of the field test. A more detailed description of *Quill* and how it affected classrooms will help make these points clear.

QUILL COGNITIVE AND SOCIAL TOOLS

Quill consists of four programs -- ***Planner, Library, Mailbag,*** and -- ***Writer's Assistant,*** which can be thought of in two groups. ***Writer's Assistant,*** a general word processor, and ***Planner*** are tools that help students become more organized and efficient in their writing. ***Library*** and ***Mailbag*** are environments that concretize certain aspects of the social environment, providing different audiences, purposes, and genres for writing. Students decide which program they want to use according to their purpose for writing and choose it from the following menu:

PLANNER Helps you to think of ideas for writing. You can take notes and get a list of your notes when you are finished.

LIBRARY Stores your writing so you can change or add to it later and others can read it.

MAILBAG Allows you to send messages to your teachers and your classmates or read the messages they have sent to you.

The following sections provide short descriptions of each program, along with examples of their use.

WRITER'S ASSISTANT

Writer's Assistant is a general word processor that students use when they are working with any of the other parts of the system: ***Planner, Library*** or ***Mailbag.*** It contains all the standard word processing capabilities: add, delete, replace, search, etc., as well as a unique facility for reformatting a paragraph of text into individual sentences so that errors of capitalization, punctuation, and structure are more visible.

PLANNER

Planner was designed to help students (1) generate and organize ideas for their writing, and (2) reflect on their writing as it takes shape. A planner consists of a series of questions or prompts that encourage students to brainstorm, organize, or revise their pieces. In addition, because students can create and modify planners as well as using them, planners can be shared and edited, just like any other piece of writing. The process of constructing a planner is, then, a metacognitive process, in which students must think about the process of writing.

To use ***Planner*** as an idea generating device, a teacher might involve students in a brainstorming session to generate a list of questions or topics to consider for an assignment. If they are writing movie reviews, the students might consider acting quality, photography, intended audience, and subject, to name a few. The teacher can make this list into a planner on the computer, so that when students begin composing their movie review, they can use it to help them start generating ideas.

At the end of a writing assignment, the ***Planner*** can help students review their work. It might ask students to identify a possible weak point in their piece or think of another example they might include. Using a revision planner students can rework a written draft.

For example, Steve and Karen are going to write a review of their favorite restaurant, Chuck's Parlor. Using their class-generated ***Planner*** for restaurant reviews, they type in responses to most of the topic questions (overall assessment, best food, price, atmosphere, location, hours, needed improvements, appropriate patrons). They print their notes on the printer and can then decide how to organize what they want to say, composing sentences and paragraphs from their notes.

Once Steve and Karen have finished the review, they can use ***Planner*** to help them revise their work. ***Planner*** might ask them if they were persuasive enough when they described Chuck's as the best restaurant, or what changes could be made to the end or the beginning of the review that would make the piece more persuasive, so that a reader might decide to visit that restaurant.

Across the room, Melinda and Jose` are working on a review of a movie. They decide to modify Steve and Karen's restaurant review planner since they feel some of it is relevant to their piece. They keep the questions on overall assessment, appropriate patrons and needed improvements and substitute for the other questions some that are more useful for their purpose, They then post a note on the electronic bulletin board using ***Mailbag*** (see below) telling everyone that they have constructed a movie review planner, in case someone else would like to use it.

Thus, even in this cognitively oriented tool, students are working in a software-facilitated social environment in which they can share writing resources. The two writing environments of ***Quill*** - ***Library*** and ***Mailbag*** - focus even more on this aspect of the classroom.

LIBRARY

Library creates an environment that enables students and teachers to share information and compositions. Students and teachers can write about any topic they choose and store their writing in ***Library*** so it is available to other computer users. Pieces of writing are organized by their author(s), title, and topic (identified by one or more keywords), just as in a "real" library. Thus, ***Library*** performs three major functions:

* It creates a communication environment in which students are encouraged to write for their peers as well as for the teacher;

* It organizes writing in different ways; and

* It provides easy access to stored pieces of writing.

Library encourages writing, facilitates sharing, and eases the teacher's record-keeping burden. A few examples will demonstrate how ***Library*** influences the social structure in a classroom.

A teacher wants to help students develop skills in giving instructions, she decides that the students will each contribute an article to a class "How-To-Do-It Manual." Leah wants to write some instructions for building a bird feeder and add it to ***Library***. She uses the ***Quill Library*** disk that contains other "How-To-Do-It" articles. She adds an entry to this disk, which already contains five articles by other students in the class. When she finishes her article, Leah types her title, "How to Build a Bird Feeder to Attract Birds," and then her name. The program then asks for one or more keywords that will give others a good idea of what her article is about. Leah looks at the list of existing keywords, generated by students who have already entered their pieces. She selects "outdoor" from the list as one of her keywords. She wants to add another, more specific keyword to the existing list. She types in the word "carpentry." The program automatically updates the keyword list, and carpentry will appear the next time anyone uses this disk, either to add an articles or read those other students have written. Her article thus becomes part of the "How-To-Do -It Manual," automatically indexed for quick referral.

Later, Arnold tells Leah he has read her article and couldn't follow one piece of the instructions. After she explains it to him, he suggests a way she might make her piece more understandable. Together, they rework the offending paragraph and save the new version. Arnold then has the opportunity to add his name as a second author of the piece and, with Leah's permission, he does. Other students will now see both authors' names when they list all the articles on this disk.

Leah used ***Library*** to add information; Jeff wants to use it to find information. He needs some information about sharks for an adventure story he is writing. He chooses the ***Library*** disk containing an animal encyclopedia his class has put together and looks through the keywords. The list is long and starts out: arctic, cats, fish, horses, whales... Sharks do not appear on the list, so Jeff decides to look at all entries with the keyword fish. After he chooses this keyword, the titles of four articles about fish are shown on the screen, one of which is called "Denizens of the Deep." He suspects the article might be about sharks, so he decides to read it. The article gives him some new information about sharks, but it is not as focused as the article he is writing. He decides to add his article to the "Animal Encyclopedia" when it is finished. Easy access to ***Library*** provides important information for Jeff's writing, as well as motivation for him to contribute his own piece to fill in a gap in the "Animal Encyclopedia."

Library provides a particular social environment for students' writing, one in which sharing, evaluating, reading, and editing one's own and other people's writing is united in a communicative framework. The structure of ***Library*** -- just as in a real library -- invites sharing because each composition is indexed in ways that invite access. In addition, students, in adding their writing to ***Library***, must confront the need to make their writing available, since they must choose keywords by which their pieces are accessed. Students using ***Quill*** often responded to this need by designating one of their five allowed keywords to "advertise" their piece, using eye-catching words such as "loony" along with a few serious keywords. ***Quill*** allowed them to demonstrate their often-quiescent knowledge of communication strategies in this way.

MAILBAG

Mailbag allows for direct communication between individual students, groups of students, and teachers. It combines features of the post office, the telephone, and a bulletin board: Written messages can be sent between individuals or a message can be posted to provide information to a group. ***Mailbag*** enhances instruction by:

*(1) Encouraging written communication to varying, but specific, audiences (for example, friends and classmates);

*(2) Allowing different kinds of writing to occur (for example, informing, persuading, instructing, entertaining); and

*(3) Motivating students to write more by personalizing the experience.

Mailbag has two complementary functions, First, students can send messages. In a classroom with an active mailbag, Jacqueline sends a message to Marilyn about a very embarrassing experience at the movies on Saturday. Matt sends a message to the Animal Club, asking for good sources of information about racoons. The teacher sends a message to all the boys telling them that a new Boy Scout troop is being formed, and giving them information about joining. Jon uses the Bulletin Board part of ***Mailbag*** to ask the class if any of their grandparents were born in this town. He has an oral history assignment and wants to interview some old timers about their schooldays in the one-room school. In each of these cases, ***Mailbag*** is an efficient vehicle for sharing and seeking information, at the same time providing opportunities for written expression that are not often present in school.

Mailbag's second function is to receive messages. In that same classroom, each student "checks his or her mail." First, students look at their personal mail by typing their name and receiving a list of their messages, selecting those they wish to read. They can then request mail for specific groups to which they belong. Finally, they can view the Bulletin Board and read messages that have been posted for everyone. For example, Maria consults ***Mailbag*** by typing her name. She has two messages, one titled "Urgent" and the other "Secret Letter." She reads both and learns that her mother has left her lunch money for her at the office (a message conveniently left for her by the teacher), and that her ardent (but as yet unidentified) admirer wants to meet her after school. When she asks for messages for the Soccer club, she finds out there is a practice on Thursday after school. Consulting the Bulletin Board, she learns that Wallie is looking for recommendations for a new adventure book to read and is soliciting opinions for and against each book suggested.

Mailbag makes concrete the ideas of "audience" and "purpose" that are so central to effective writing. Students cannot use ***Mailbag*** without specifying an audience, as that is as much a part of using this environment as addressing a letter is in the real postal system. Moreover, their audiences are real (fellow classmates and teacher) and are likely to respond. In several classrooms, teachers found that students communicated with them in ways they hadn't in the past, making suggestions about scheduling (one student said he liked having the week's schedule on the blackboard) and subject matter (another student requested more time for art instruction). Some of the most interesting ***Mailbag*** entries are probably those no one will ever read; in several classrooms, teachers told students that the Mailbag is "private" and that no adult would ever eavesdrop on their electronic conversations. Not surprisingly, those disks filled rapidly -- but the teachers have yet to see what is on them.

THE SOCIAL CONTEXT REVISITED

Quill, then, attempts to design the social context of a classroom to encourage real communication, focus on audience and purpose, revise with clear reasons, and develop a literate community. Of course, the teacher plays a large and critical role in determining the characteristics of the interactions that evolve. Some teachers who used ***Quill*** were uncomfortable with the fact that students wrote "love letters" using ***Mailbag*** and eliminated that aspect of the system. Others used the structure of the software and accompanying suggestions in the teacher's guide as a starting point for enriching writing instruction in their classrooms in ways that went far beyond the software. Some of the projects that emerged from these classrooms included: a book of love stories to inanimate objects (inspired when the teacher confided to his class that he loved his bright red sneakers!); a series of TV plays, written by a group of four sixth-grade girls; a community calendar, decorated by pictures and student poetry and containing the birthdays of all 50 village residents; and several monthly classroom newspapers.

The most interesting results, however, were those unanticipated interactions among the computer, the software, and the classroom. In one classroom, a series of events led to a sixth-grade girl's discovery that there are often real and important reasons for revision. The entire class had attended a school-wide Black History Show in the auditorium and when they returned, the teacher announced an optional assignment: write a review of the show. Those who chose to write could use ***Quill*** to produce a final version of their review. Students got access to the computer in the order they finished their first drafts. One girl, Margaret, included the following paragraph in the first draft of her review:

> "The scenery was pretty good, and the light was bright enough, but the sound was not that good. Mr. Hodges was speaking very loudly and was good on the stage. I think the show deserves three stars because it was very good."

While Margaret was standing in line to use the computer, her friend, Marines, finished a draft and joined her. Margaret read Marines' rather negative review, which contained the following paragraph:

> "I don't know what happened to the Glee Club, they were almost all weak. The audience couldn't hear them. They sounded soft then they

went loud. It was a disaster!"

When Margaret had her turn at the computer, she made several changes to her review. Some were minor, but there was one major change. In the middle of the paragraph included above, she inserted several new sentences. The piece then read:

> "The scenery wasn't much, and the light was kind of dull, and the sound wasn't very good. Mr. Hodges was speaking loud and clearly, and he was great on the stage. When the Glee Club was singing so nice, Marines got very jealous and asked Mrs. Evans to be in the Glee Club. But when Mrs. Evans said no she wrote bad things about the Glee Club on the computer upstairs."

Margaret had made a quite substantial revision to her review. It was motivated not by a teacher telling her that revision is an important part of effective writing, but her sense that her audience (the class) would want an explanation of the discrepencies between her review and Marines's. This is the very essence of good writing: the incorporation of critical reading and audience awareness into the writing process. The contributions to this powerful lesson for Margaret were many -- the computer (which created the need for a queue in which she read her classmate's piece!), the teacher, and the social context all contributed in important ways. It is this interaction that must be at the center of future software design and research, into the place of technology in education.

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THE IRIS PROJECT: CONSTRUCTING MODELS OF COMPREHENSION

by James E. Schnitz

INTRODUCTION

Throughout the past three decades, the topic of reading comprehension has generated a lot of rhetoric among reading professionals. Until recently, however, little substantive work has been done either to articulate theories about cognitive processing and comprehension or to build strategies for teaching comprehension.* Pearson (1985) reports that as late as 1970, many scholars doubted that comprehension skills could be taught, while those who disagreed believed such skills were learned in highly specific ways. No coherent theory or supporting research about comprehension drove instructional practices. Rather, instruction about reading comprehension was guided by assumptions about the categories of specific questions and the benefits of completing worksheets based on literal recognition of information.

It has only been within the past decade that theories have begun to emerge as frameworks for understanding reading comprehension. Constructs such as schema, hypothesis testing, frames, scripts, story grammars, metacognition, and metacomprehension have all appeared as coherent, explanatory propositions about the processes of comprehension (Pearson and Gallagher, 1983). Only recently have the first instructional materials based on these constructs (often referred to by the umbrella term "schema theory") become available.

One of the earliest and most influential attempts to build curricular materials in reading comprehension using schema theory was IRIS (Individualized Reading Instruction System). The purpose of IRIS was to demonstrate the effective use of computer-assisted instruction in reading comprehension by joining two parallel developments in education: the new, articulated theory of comprehension and the new microcomputer technology.

SCHEMA THEORY

In designing the IRIS program, WICAT viewed the merging of schema theory with microcomputer technology as not only a means of demonstrating state-of-the-art CAI, but also as a means of demonstrating state-of-the-art reading comprehension instruction. In simple terms, schema theory holds that comprehension is an interactive process in which the reader understands the author's message when he or she can relate the message to what he or she already knows. From the standpoint of instructional design, providing readers with strategies for reconstructing the author's message becomes paramount. Schema theory offers a frame of reference that focuses on the reader's cognitive behavior relative to the text rather than on the nature of the teacher's question.

This is not to suggest that taxonomies of questions and objectives are inherently flawed; it is merely to indicate that taxonomic renderings of reading objectives do not necessarily lead to productive instruction in reading behavior. As Bloom and his colleagues themselves indicated:

> ...the taxonomy might lead to fragmentation and atomization of educational purpose such that parts and pieces finally placed into the classification might be very different from the more complete objective with which one started...(1956, pp. 5-6)

This was the recognized danger which the authors of the taxonomy hoped to avoid by creating a "level of generality where the loss of fragmentation would not be too great" (1956, p.6). In fact, the level of generality was clearly insufficient to prevent fragmentation. The objective "To read significant writings with critical comprehension," (Bloom, et.al., 1956, p.48) is classified as Interpretation "...since this is the subcategory of Comprehension which emphasizes the grasping of the meaning of a written work" (ibid). What the taxonomy offered was a means of categorizing, and hence, reporting on, specifics. It offered no means for instructional decisionmaking in the face of a set of complex processes.

To understand how schema theory can inform instructional decisionmaking in reading, consider this sentence:

> The notes were sour because the seam was ripped (Bransford and

McCarrell, 1974).

Most people find the sentence confusing as given. It is a complete sentence, but as is the case to some degree with all written communication, it is fragmentary in its transmittal of message. The problem of understanding the sentence is bound up in the problems of piecing together the fragments given with the fragments implied or ignored. No wonder that students confronted by text which, to them, is as meaningless as that given above, respond to questions such as "Why were the notes sour?" with the syntactically accurate, informationally meaningless, "Because the seam was ripped."

The problem is not in the taxonomic level of the question asked; it is in the absence of a model of processing that the question implies. Consider an alternative question: "Where might the sentence most likely be spoken?"

The most striking feature of this question is that its answer lies totally outside the realm of the specific text of the sentence. To answer the question, the reader must not only understand the intended meaning of the sentence, but must also relate the meaning to other categories of knowledge about the world possessed by the reader. To do that, he or she must go through a process called *instantiation* in which the elements of the sentence are used to build constructs called *schemata,* whose interrelationship can then be explored. "Notes," for instance, is an ambiguous noun that might refer to a brief letter, a set of written reminders, or elements of music. The modifier "sour" constrains meaning to suggest either a negative communication or off-key music. Since "sour" is much more frequently used to describe music than text (though spoken and nonverbal communications may well be described as having a sour tone), it is likely that one schema in the sentence is music.

What, then, of the ripped seam? "Because" indicates causality, so the "ripped seam" pertains to the instrument producing the off-key music. Though "seam" could indicate a stratum of ore, it would more normally suggest the joining of material, particularly with the added context of "ripped." Hence, the instrument producing the off-key music is probably made of cloth, perhaps a bagpipe.

Now, with the instantiation of the schema for "bagpipe," the original sentence makes sense. Moreover, using additional meanings the reader may associate with the bagpipe schema, elements such as kilts, plaids, the highlands, or any of a number of related concepts, the answer to the question of source locale becomes readily accessible: Scotland.

Though simplified here, the crux of the comprehension process lies in the ability of the reader to instantiate the schemata intended by the author, and then to find relationships among the schemata. Of critical importance to facility in the comprehension process is the reader's awareness of how he or she is reasoning about text, a skill sometimes called *metacognition*. When the reader possesses a model for reasoning about text, comprehension is enhanced. Processing difficulty occurs either when the reader has difficulty relating the elements given by the author to any preexisting schema (what instrument is made of cloth?), or when the reader cannot find the logical relationships inherent in the juxtaposition of the implied assumed schemata (the reader knows neither that bagpipes originated in Scotland, nor that the point of the instrument's origin is relevant). The latter difficulty is augmented when the conclusions called for by the reader are cognitively remote from the author's text, or when the relationships among schemata are unusual.

The implications of schema theory for the IRIS program were clear, and from the standpoint of CAI, extremely advantageous: develop models of reasoning about instantiation and logical relationships among both near and remote schemata, and both the interactive structure of online activities could be defined and the quality of comprehension could be improved through direct instruction in the process by which comprehension occurs.

THE IRIS PROGRAM

The ***IRIS*** program was conceptualized as a set of interactive structures, called protocols, in which students could perform operations on text from the frame of schema theory. Each protocol would represent a model, or strategy, for considering text. Several assumptions substructed the design of the protocols and their functions:

* Because context is fundamental to comprehension, isolated sentences and paragraphs would be avoided in favor of entire passages and stories.

* Because background knowledge is the essence of preexisting schemata, as broad-ranging a set of stories as financing would permit would be used. This would minimize the number of times the absence of background knowledge would preclude comprehension, and maximize the vicarious expansion of background knowledge.

* Because authors of articles and books are not bound by a 40-character, 19-line screen, authors would be hired to produce stories explicitly for the program.

* Because vocabulary knowledge is fundamental to comprehension, one protocol would address vocabulary development.

* Though lists of discrete skills would not be used to define the strategies modeled in the protocols, they would be used to insure that the questions attendant to the tasks reflected the elements most familiar to teachers.

* Instructionally, the protocols would step a reader through a strategy of reasoning about text, providing helps and explanatory feedbacks to show the reader how to use the strategy.

* Metacognition would need to be demonstrated to and by the reader by manipulating specific elements of text.

* Helps would need to focus on instantiation by highlighting the key elements for the intended schema and by showing the logical path to the key relationships.

* Helps and feedbacks would have to be more direct, shorter, and use simpler vocabulary than the actual task.

* To be effective, instruction must be managed. Hence, an on-line manager would be necessary that would allow the teacher to register students, configure elements of the curriculum, and provide status reports of student performance.

With these as guiding principles, the development of IRIS proceeded.

IRIS, in its final form, is organized as a mock newspaper to account for the wise disparity of topics and to provide a familiar setting for the student in which to carry out the reading tasks. Five different protocols exist with 210 different stories/vocabulary exercises. To use the program, a reader enters his or her name and password, enabling the program to track and record performance. The student then sees a display called Newsstand, which lists a menu of mock newspapers.

Each newspaper consists of five stories or exercises. The newspapers are organized by grade level of readability (standard readability formulae, concept density estimates, complexity of task variables, and content appropriateness were all part of the readability estimate) and protocol type. The menu presented to the reader is controlled by his or her current level of achievement if the program recognizes the user as a fifth grade level reader. He or she will see a menu listing for third, fourth, fifth and sixth grade level stories ranging from two years below to one year above his or her current level of achievement. The reader's achievement level is constantly monitored, and is incremented one year if he or she scores 80 percent or better on an exercise above his or her current level of achievement. The reader's achievement level is decremented one year if he or she uses score below 50 percent on any exercise at or below his or her current level of achievement. The newspapers focus on fifth grade content, but range in readability from third or seventh grade.

After the reader selects a newspaper from his/her menu (which is directly controllable by the teacher through the online manager), a front page display appears.

The reader can then select from among the five stories presented. The stories will require that the readers interact in one of the following models:

<u>Inference.</u> The reader is shown a frame of text with a multiple choice question. When the reader answers, he or she is asked to justify his or her response by selecting keywords from the text that led him or her to respond as he or she did. Both the answer to the multiple choice question and the choice of key words are checked, and feedback explaining the logic of the correct answer is provided. A summary question is asked at the end to help the reader synthesize the story meaning.

Deletion. The reader is first presented with a scenario. He or she is an editor for the newspaper, the writers for which are marginal competence: they have written stories with sentences that don't belong. The reader's job is to find those sentences and remove them from the story. To do this, the reader reads the story through to ensure a frame of reference for judging significance, relevance, mood, tone, and order. He or she then moves a cursor through each page a sentence at a time, pressing a key to draw a line through any sentence that fails to serve the author's purpose. The student can get hints regarding the category and number of offending sentences, and receives feedback explaining why sentences should be removed or retained.

Graph Interpretation. The reader sees a story in which non-textually organized data is presented. Graphs, charts, tables and maps are all used in the protocol. The reader reads two to three frames of text, and then responds to a predictive question designed to help him or her pre-organize the information contained in the graph to be viewed. He or she receives feedback, and then is shown the graph. Five to eight questions are asked, each of which the reader answers by moving a cursor to the correct response on the display. Clues are provided when requested or when the reader misses on a first attempt. A summary question is asked at the end to tie together the textual and nontextual information.

Argumentation. The reader is given an editorial and is asked to perform five tasks. The first consists of reading the beginning of the letter and identifying the writer's point of view. Second, prior to reading the argument, the reader identifies the necessary and sufficient conditions for accepting the writer's point of view. Third, he or she reads the editorial and tests each page to see if the writer addresses the established conditions. Fourth, the reader determines if statements of fact or opinion were used to address the conditions. Finally, he or she decides whether or not the argument was valid. Helps are available for determining whether or not a condition was addressed and for categorizing presentations as fact or opinion.

Vocabluary. The reader sees a crossword puzzle organized around spelling patterns. Two clues are available for each word, and the reader can "buy" letters as well. When the puzzle is finished, the reader answers an open-ended question regarding the meaning of the root pattern for the puzzle, Finally, using the meaning of the root pattern and the meaning of combining morphemes, the reader analyzes the probable meaning of new words.

IRIS AND MODELS OF COMPREHENSION

Though ali of the activities described above derive from schema theory, perhaps the inference protocol best demonstrates how schema theory can be translated into interactive strategies as models of comprehension.

JAN'S SECRET

Jan sat on the park bench pretending to read her book. This was the last day of summer vacation; tomorrow she would start 6th grade. Usually, she was excited to start back to school, but this year was different. She was different. And tomorrow everyone would know her secret.

Jan feels

1. happy

2. angry

3. worried

4. excited

<Pick one by number>

At the outset, there is little difference between this task and many others where the student is asked to draw a conclusion from the implications of a passage. The difference lies in what happens after the reader has selected an answer.

JAN'S SECRET

Jan sat on the park bench pretending to read her book. This was the last day of summer vacation; tomorrow she would start 6th grade. Usually, she was excited to start back to school, but this year was different. She was different. And tomorrow everyone would know her secret.

What words make you think so?
Type <-, ->, and D to copy or delete words.
Type CTRL Q to see the question again.
Type RETURN when you are finished.

Schema theory, as indicated above, shows the importance of instantiation and metacognition to the comprehension process. Where the reader can justify conclusions by indicating the key words in the text that lead to the reader's decision, the reader can establish control over his/her own comprehension process, and over a mechanism for checking out decisions. Hence, the student is not given feedback about the multiple choice response until he or she has completed key word selection; indeed, based on analyzing the text for specific indicators or meaning, the reader can choose to return to the multiple choice task and select another answer.

JAN'S SECRET

Jan sat on the park bench pretending to read her book. This was the last day of summer vacation; tomorrow she would start 6th grade. Usually, she was excited to start back to school, but this year was different. She was different. And tomorrow everyone would know her secret.

Your answer is correct, and we have chosen some of the same words.

Your words were:
<secret>

My words were:
<usually, excited, but, different, secret>

Type CTRL Q or RETURN

JAN'S SECRET

Jan sat on the part bench pretending to read her book. This was the last day of summer vacation; tomorrow she would start 6th grade. Usually, she was excited to start back to school, but this year was different. She was different. And tomorrow everyone would know her secret.

How does Jan usually feel about going back to school? What about this year? Why? I think Jan is worried.

Type CTROL or RETURN

When the reader has signaled completion of both the multiple choice and key word selection tasks, the program provides feedback, including an explication of the line of reasoning through the entire story, using instantiation, logical chains, and awareness of specific indicators of meaning (metacognition) to build a strategy for comprehending text.

THE IMPACT OF IRIS

Though IRIS was among the first instructional applications of schema theory, it has not itself been widely distributed. Comprised of a set of 55 disks for use on stand-alone Apple IIs, the problem of maintenance and customer service has impeded its use. The algorithms on which IRIS was based have, however, had a broad impact on reading comprehension CAI. PLATO/WICAT distributes a reading program that is derivative of IRIS while IBM has selected IRIS-based algorithms for its reading comprehension product line. Increasingly, the standards for instruction set by IRIS are becoming the industry standards for producers of reading courseware.

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THE STORY OF "STORYLORDS": DECISIONS IN THE CREATION OF AN INSTRUCTIONAL TELEVISION SERIES

by Thomas DeRose and Martha Deming

Norbert: Who are you?

Lexor: I am Lexor, Storylord of Mojuste. And you?

Norbert: I'm Norbert...boy of Wisconsin.

Lexor: Norbert, there is no time to lose. The wicked Storylord, Thorzuul, seeks to conquer my planet. Then he will attack yours!

I am old -- my time in this body is short I need an Apprentice Storylord to help defeat Thorzuul and save both our planets. Will you accept the challenge?

Norbert: Well..sure, I...But I have to be home by dinnertime.

So begin the adventrues of Norbert in the instructional television series "Storylords," which introduces second through fourth-grade students to reading comprehension skills. In order to defeat Thorzuul and save the citizens of the planet Mojuste, Norbert must learn and apply reading comprehension strategies to the problems Thorzuul poses.

As with any instructional television series, "Storylords" was created to present certain information to a specific audience in order to meet an educational need. In the case of "Storylords," research within our state indicated a need for a reading series for the lower primary grades. Consultations with reading experts established that the series should present a set of reading comprehension strategies that an accomplished reader would apply -- strategies such as activating prior knowledge before starting to read, making inferences by combining what you know with what's on the page, defining an unknown word through its context, and so on.

Children in grades two through four were the selected audience for the series. Like any other audience, this group must be treated appropriately for its age. Cognitive development must be considered; the amount of information that can be presented and the pace of presentation must be balanced; and a story line must be selected that will be appealing to this age group.

The plan for "Storylords" was to present the reading-comprehension strategies in such a way that age group would understand and appreciate their use. In addition, we expected "Storylords" would introduce this new reading comprehension curriculum into the classroom The series would teach the students <u>and</u> the teachers. After all, teachers would have the ultimate responsibility of working with students on the strategies and of applying them to the print materials already in use in the classroom (basal readers, subject area texts, storybooks).

In designing and developing "Storylords," it was necessary to consider the content to be presented, the intended audience, and the series's goals and objectives -- all of which will be examined in greater depth later in this article. Underlying these considerations was an understanding of the nature of television as a medium for instruction.

<u>TELEVISION AS AN INSTRUCTIONAL MEDIUM</u>

The power <u>and</u> limitations of television dictate to a large degree what can be done in an instructional television series. Television is good at holding and focusing attention, systematically presenting ideas, and maximizing the efficiency of presentation. On the other hand, television is basically unidirectional (i.e,noninteractive); it must satisfy the least competent viewer; and it is largely limited to presenting abstract ideas through concrete examples. Furthermore, users of instructional television usually prefer that programs be limited to about fifteen minutes of viewing time, certainly not long enough to do any real teaching.

How is fifteen minutes enough time to effectively change students behavior? Moreover, we should not expect children who watch instructional television to be able to perform according to what was presented in the program. Television may not be the best medium to accomplish changes in performance; teachers themselves, in their personal interactions with students, are much better at doing this. What television can and should do is to present a concept (in the case of "Storylords," a reading strategy) in such a way that the student is able to understand and appreciate its use. Then the teacher can teach the student how to apply the strategy.

An exception to this general rule might be instances where an instructional television program presents a very limited amount of information, such as what the letter "A" looks like, and what is sounds like. We are all familiar with the great success of "Sesame Street" in this area, conclusively demonstrating that such basic skills can be taught through television. However, the learning of more complex conceptual knowledge within a 15-minute period of time cannot be accomplished, certainly not in any measureable way.

What, then, should be expected from a 15-minute instructional television presentation? The answer to this question has a tremendous impact on the design of a program.

Perhaps the best way to describe what can be expected is through an analogy.1 In a typical trigonometry class, a teacher may prove a theorem at the board. The hope is that the students will understand the proof. We might expect one to say: "Oh yeah, I get it!" However, we would not expect the student to then be able to perform the proof. This ability would come only after repeated attempts and much practice. Nevertheless, though we would be unable to measure the students' understanding of the proof, we would feel comfortable knowing that they "got it."

Applying this analogy to instructional television, we expect that after viewing a program students will be able to state that they understand the message. Perhaps they will be able to explain how they came to understand the message -- what elements of the program made it understandable to them. But, in most cases, they will not be able to demonstrate an ability to perform according to the message.

1. The authors are indebted to Leonard Waks for this analogy.

Let's apply this principle to "Storylords." After viewing the video program which introduces the strategy of identifying the elements of a story, students may say: "Yes, I understand it." Students may be able to explain what they understand. A st ry must have six parts: setting, characters, problem, goal, episodes, and resolution. Without these, it isn't a story. They may be able to say why this is important to know ("Knowing story structure helps understand a story") and even why they think this is so ("When Mandy had to solve the problem, she used what she knew about story structure to do it"). However, if asked to identify the elements of a story and to show how this helps to better understand the story, the students would probably fail. This ability will come only after much work with stories under the guidance of a teacher.

A 15-minute instructional television program, then, can create understanding in the audience without necessarily bringing about measureable changes in behavior. This understanding contributed to the decision made in the development and design of "Storylords."

THE CONTENT: READING-COMPREHENSION STRATEGIES

"Storylords" was developed to improve reading comprehension (and reading comprehension instruction) in grades two through four. Studies of reading comprehension have shown that while a good share of classroom time is devoted to reading, only a very small amount of time is spent in actual instruction on reading comprehension. It is as if teachers believe that reading comprehension will come naturally or not at all.

Recent research has identified comprehension strategies employed by competent readers, some of which are already taught in regular reading instruction (e.g., identifying a main idea and supporting details) and some of which have traditionally been left up to the reader to develop "naturally" (e.g., improving understanding by connecting what you already know with what you are reading). It is believed that a skilled reader carries about this set of strategies and, either consciously or automatically, applies them where appropriate. If the strategies can be used by young readers, their ability to comprehend what they read should improve.

The goal of "Storylords" was to present these strategies in such a way that students would adopt them and incorporate them into their regular processes of reading comprehension. Numerous factors had to be considered in the design of the series in order to achieve this goal.

THINKING ABOUT THINKING

Reading can be thought of as a process in which the reader continually experiences new problems to solve: determining who the main character is; understanding a new, unrecognizable word; finding answers to questions. In order to solve them, the reader must be able to recognize the problem, identify it as a specific problem, decide on the appropriate strategy, apply the strategy, consider the success of the application, and reassess any or all of these steps as necessary.

Such introspective problem solving and strategic behavior requires that the reader reflect on his or her mental processes. Metacognition, as this process is called, poses problems for the second- or third-grade child. These young children do not understand what to do when directed to think about their thinking processes. It is not that they cannot think about thinking; they do it all the time. But they cannot consciously pause and consider their own thinking. This ability develops later. So we could not simply introduce metacognitive strategies to the audience.

THE AUDIENCE: BEHAVIOR MODELERS

Children of this age are quite competent at observing and copying the behavior of others. Certainly this modeling behavior of those around us is a significant part of human development. In fact, the research into the effects on children of violence and other antisocial behavior seen on television shows that children do model the behavior they see.

Our task, therefore, was to create situations in which characters would find themselves in a problem situation that would require the application of the appropriate strategy to resolve. To facilitate modeling, the situation would have to be identified by the audience as desirable or attractice -- one in which viewers could imagine themselves.

FANTASY: GETTING AUDIENCE ATTENTION

We wanted to create a situation in which reading problems would have tangible consequences, as well as one to which the audience could relate. Certainly today's children have a good deal of experience with, and are very fond of, fantasy action adventures. The enormous popularity of "Return of the Jedi," "He-Man," "She-Ra," and "GoBots," to name a just few, attests to this. We decided our story would involve a fantasy action adventure related to reading.

Briefly, the story is this: An evil wizard, Thorzuul, is attempting to gain control of the planet Mojuste by finding those who cannot read well and turning them to stone. The good Storylord, Lexor, enlists the aid of Norbert, an average boy. Whenever someone is stuck on a reading problem posed by Thorzuul, Norbert is summoned to Mojuste. where he must determine the problem and use a reading strategy to solve it. Such a context creates a situation where the problem is significant and warrants the attention of Norbert and the audience.

THE CLASSROOM: GROUNDING IN REAL LIFE

The next task in developing this series was to determine how to provide Norbert with the appropriate strategy to apply to solve the problem and thwart Thorzuul. Perhaps like Norbert, many children judge the usefulness of school by the relevance school to has for them. Therefore, it is appropriate that Norbert acquires the information he needs from his teacher, Mrs. Framish, and from classroom reading instruction. This approach helps the audience see and appreciate the value of education for solving problems that are important to them.

While the situations in which Norbert finds himself on Mojuste capture attention, they are not a part of the audience's everyday life. To bridge this gap, i.e., to show the audience how these strategies do relate to everyday life, each program also contains an earthly problem which is solved by the application of the same strategy that to solve the problem on Mojuste.

DECISIONS ABOUT CHARACTERS

Because boys have more reading problems than girls, it was decided that the main character should be a boy. This character, Norbert, would have to be someone with whom our audience could identify. Norbert is not perfect. He is a little overweight, a little "frumpy." While interested in sports, he does not excel in them. He likes to learn but isn't enthusiastic about school.

In order for there to be an exchange of dialogue with Norbert, he was given a frier.., Jason. Jason is a little more practical, not as prone to fantasy. (Perhaps that is why Lexor chose Norbert and not Jason to be his apprentice.)

Field-testing while the series was under production indicated a potential problem in the fact that the two principal characters were boys. If the situations being created were ones in which boys would be more likely to be found, girls in the audience might have difficulty identifying with these boy-type situations. This finding prompted the creation of Norbert's sister, Mandy. Mandy is a year or so younger than Norbert, in some ways more capable and in some ways less capable than he is. While Norbert often provides guidance for Mandy in reading comprehension skills, Mandy has abilities of her own. She can, for example, throw a football with a perfect spiral.

The addition of Mandy to the cast prompted the creation of situations with which boys and girls could identify. In fact, Mandy accompanies Norbert on trips to Mojuste and, in several instances, thwarts Thorzuul completely on her own.

THE ARTISTIC ELEMENT

As has been seen, learning or developmental theory contributed to the design of "Storylords" at every step along the way. However, while those involved in developing and producing the series were knowledgeable about learning child development, and reading comprehension, they also had experience with what captures the attention of children and what makes good television. Art had as much to do with the development of the series as did science.

Science and art combined, for example, in the selection of the actor who played Norbert: he not only fit the instructional needs of the series but also "looked right" and was easy to direct. Among the artistic elements to capture the attention of the audience and make them <u>enjoy</u> watching are special effects (Norbert's space-travel machine), costumes (Thorzuul's broad-shouldered cape), props (Storylord gloves), music (Thorzuul's entry theme), and comedy (Thorzuul's sidekick, Milkbreath).

Television is an artistic medium; ignoring this fact in the development of instructional television can limit both its effectiveness and its appeal. Ultimately, the success of "Storylords" at accomplishing what it sets out to do will be determined by how well the series blends science and art.

COMPUTER USE AND HUMANITIES TEACHING

by Benjamin H. Thomas

I have spent a half-year sabbatical looking at computer use in humanities and social science classrooms, and know that I will learn more. At this point, I see one potential direction of computer-oriented education and I hope the ideas and examples on these pages will help teachers argue for their own stand-alone personal computers when their schools are handing them out.

I have long believed that the tool software will have a far greater impact on education than other uses such as CAI. I have, therefore, been looking at the applications of standard software -- word processing packages, database management programs, spreadsheets -- to humanities teaching. I have also assumed that I will not be in the near future at least, in a classroom with personal computers for every student and that I and most teachers can expect to have regular access to one personal computer at best. Finally I have assumed that personal computers can and will be used by teachers to generate their own curricula, either out of whole cloth or by working variations on a textbooks or package unit.

I am convinced that students need to be allowed to play on computers, to make mistakes, to be as creative as they wish to be, to work together. The same holds true for teachers -- use a computer because you want to, because it is fundamentally fun. Teachers should resist accepting a computer because someone says they have to, or because they feel they ought to. I have not found computers to be time savers, at least in the short run; I have often been extremely frustrated by my own ineptness in making a personal computer work for me, and I have not always found the necessary preparation time to use one most effectively. On the other hand, I have had fun working with the machine -- often I work more accurately, more thoroughly, and become more involved in the task ahead. What more can I ask?
And from comouters come new and intriguing variations of what I have always tried to do -- to make students think, see connections and ask

questions.

WORD PROCESSING SOFTWARE IN THE CLASSROOM

For humanities classrooms, word processing software is the most obviously useful tool, and the one which current use is closest to what we will see five years from now. Depending upon the age and background of their students, teachers may already have a significant percentage of their students doing writing assignments at home on a word processor. For the teacher or preparer of assignments, tests, reports and letters to home, word processors are an inestimable worth. Many teachers are already using them to the fullest, saving their work on a disk for easy revisions the next time the unit is taught, making notes on the assignments after the unit is completed. The magic of the word processor is, of course, ease and cleanliness of revision; teachers love it, students love it, and better papers get written.

I want to describe a use of word processing software that is somewhat different, to suggest that its virtures have an application wider than we have found so far. This is an account of a unit that I have prepared and taught during my sabatical to four classes of seventh and eighth graders at the Sidwell Friends School, an independent Quaker school in Washington, DC, in April of 1986. My primary objective was to try a unit that used a word processor in teaching the writing of poetry.

Working with Sally Selby and her four classes of vertically grouped seventh and eighth graders, I developed an approach to teaching poetry that I hoped would encourage the students to see their poetry as more of a process than a product; one that would produce poets as much as poetry. It is the experience of many teachers that students are fiercely protective of their own writing, especially poetry; that the rough draft and the final are the same and that revision is punishment. Here is where the word processor came in. It was our hope, supported by the experience of others who had worked with the students in their writing, that the ease and neatness of the revising process would encourage students to revise their work more freely.

We began by looking at several poems by recognized authors, on monitors. This was in part little different from what would have happened if they had copies of the poems in front of them -- we looked at all the proper things -- images, allitieraton, rhythm. We also looked at the word selection by generating a list of synonyms for a critical word in one of the poems and then inserting it into the poem on the screen; of all the efforts to look at "real" poems, this was the most successful -- the effort to look at different line length and word positions meant little to either the students or two teachers in the classroom. In our opinion, students started to see, at this point, the power of the right word at the right place.

We had asked students to write their own poems from the outset of the unit, and they read out loud these exercises in class. Each day I put some of their poems up on the screen for discussion. The thrust of this was to look at what worked and what didn't, according to the intent of the students. I had read an article in the Washington Post in the Fall of 1985 about the use of ThinkTank in meetings, which suggested that participants in a meeting where the focus was on the screen (in that case, one which showed the organizing program) were notably cooperative and relevant in their contributions With that in mind, I hoped that the competitive element always present in the classroom would be dampened by the presence of the monitors; in fact, there were few pejorative comments about the poems that came up on the screen. Some students wanted to rewrite another's poem their way, but without saying or implying that their way was necessarily better. We continued to use the word processor to support and examine alternatives.

As a final assignment for the unit, we asked each student to produce the best poem that they could. Their rough drafts went into the computer as soon as they came in, sometimes typed in by me, sometiumes by students themselves. (Interestingly, there were few students who wanted to play with the machine; even fewer who really knew how to use it.) This was the beginning of a process that continued for several days; I would sit with students at the computer and we would discuss their poems, what they liked, what they didn't. Some of the changes were explored on the spot, but often I would ask them to go home and work on one line or section overnight and come in with revisions the next day. The success of this varied with the student, but there were many who sought me out eagerly, before school or during free time to get their changes onto the screen. While I worked with individuals, other students worked on their poetry in pairs, or by themselves, or with the other teacher. A friend commenting on the process said that she had never been given the sense that revision was part of the writing process when she was in school; this unit seemed to her to clearly communicate that idea. She also noted that the way in which the teacher and student worked together at the computer created an entirely new relationship, and that she had never seen teachers used as resources to the extent that this process mandates.

At the end of this process, when all students had a poem entered and revised on the disk, we printed them out and copied them so that each student had a copy of the anthology of student poetry. This is yet another example of the value of the computer for compiling and producing collections of student writing.

Students did not endorse the use of the computer wholeheartedly -- a few (perhaps one out of four) expressed revulsion at the mix of poetry and computers-- of soulful art and souless machine -- and that attitude had not gone away at the end. There was little we could do to combat that, and we did not worry about it very much.

For myself (both teachers did the assignments to students), writing poetry seemed as easy on the computer as by hand; I was much more ready to revise it, and I found myself experimenting to a much greater degree than I would have done under ordinary circumstances. It may be worth pointing out, however, that only one student did the first draft on a computer (at home), and that what we were about was revision rather than writing. That aspect of the process was clearly successful. Ms. Selby who had done little work with computers before, was in agreement with me that the students' work was significantly better as a result of the extensive revising.

In sum, it worked in the ways that I had hoped for. Poetry writing lends itself to this as a classroom exercise due to the brevity of the student input, of course; I would not try this with a four page essay. There were other advantages -- our class size was between 12 and 16, and there were two experienced teachers in the classroom at all times. I believe, however, that the screen did hold attention well, that there was a sense of collective endeavor, and that students did help each other to a significant degree. Two teachers and small classes are no prerequisites for this kind of work.

There were a number of additional ways to use a personal computer in this unit -- we did nothing with random generation of poetry, for example, nor did we track any of the student work with the personal computer -- but the essential task of getting students to write and revise poetry was successful. I would do it again, I hope, and believe that Ms. Selby would do it again, and this kind of computer use will spread to other classrooms in the school.

SPEADSHEETS AND DATA BASES IN SOCIAL STUDIES

Use of other standard software tools is far behind that of word processing, but they also hold potential for exciting changes in teaching. I am dazzled by the spreadsheets and database management programs. The cause-and-effect relation and the "what-if" kind of thinking that they generate is what I have always tried to get my students to do. In another of the experimental units that I taught in the course of my sabbatical, I worked on database building. The topic of the unit I taught was social stratification; I joined a class of eighth graders after the students had read a chapter on that subject in their sociology text. With Alan Braun, their regular social studies teacher and me in the classroom for the rest of the unit, the students read Working by Studs Terkel, with each student specifically responsible for about 10 of the 133 interviews in the book, relating it to what they had learned from the sociology text.

In my first class with the students, I explained what a database was, comparing it to the expertise that a doctor builds up by training and practice, with each experience being a file in the doctor's database. We would be looking at the interviews in Working and combining what each of the individuals had to say about their job to build a picture of what the book as a whole said.

After a week of general discussion about the book, we developed questions to be answered by each student for his or her assigned interviews. Questions were to some extent factual (sex, approximate age, race if known), but many of them called for judgements on the parts of the student (how the subject liked the job on a scale of one to five, what were the motivations for taking the job). We added numerical prestige ratings from a survey done in 1980, and the Equal Employment Opportunity Commission job classification rating. Students accepted readily that all their responses had to be numerical or multipe choice in form.

When the database was complete, we looked at the results with the computer in the classroom. Students could ask to see the correlation between answers to any pairs of questions; or to see what one discrete group said as contrasted with the entire set of interviewees. For example, the workers in the highest stanine of prestige did not have a correspondingly high level of job satisfaction; blacks and women tended to share negative attitudes about their jobs; other similar results were equally interesting and thought-provoking for students.

I had doubts during the unit about the validity of a database built on student responses of inconsistent accuracy. I considered using a similar assignment where students gather only factual material. The students, however, clearly believed that entering their own opinions mattered a great deal. I was completely reassured by the time the class spent in querying the database. Students spent their time looking at connections, trying out hypotheses, thinking analytically and creatively. This is what I ask students to do all the time, of course, but I have never used a technique that offered them as much direct feedback on their effort as this one.

ASSESSING CURRICULUM MATERIALS

One of the first software packages that I used was Lotus 1.2.3, the standard spreadsheet. I have not used it in a classroom, but I did use it to assess units in my curriculum. Attached is a simplified copy of the worksheet

As you can see, there is nothing magic about this, but I found the results interesting and helpful. A group of teachers can use this technique effectively as a preparation for discussion and decision-making about text books, for example. The number rating is the least important element· the making of the worksheet and assigning weights to the categories is itself worthwhile and may clarify thinking enough to make the discussion of the numeric outcome quite quick.

There are other useful packages, and many more will appear in the next few years. Let me mention two briefly. The first is an outlining program, such as ThinkTank, refered to already. It's value to individual students is obvious, but it is also used very effectively in focusing discussion, as long as all students can see the screen.

FIGURE # 1

CURRICULUM EVLAUTION SHEET

TOPIC	WEIGHT*	GEOGRAPHY UNIT	WORKING UNIT	INVENTION UNIT	ECONOMIC UNIT
		RATING			
FACTUAL CONTENT	5	5	4	5	3
CONCEPTUAL CONTENT	5	4	5	5	3
NON-VERBAL WORK	3	5	1	4	2
GROUP LEARNING	4	4	4	4	4
FOR WIDE RANGE OF ABILITY	5	3	5	5	3
QUALITY OF TEXT/ READINGS	5	4	5	3	3
PRODUCES GRADABLE WORK	2	3	4	4	2
ROOM FOR GRAPHICS	3	5	1	5	1
GOOD USE OF COMPUTERS	2	1	3	4	4
LINKS W/ENG CURRICULUM	2	1	4	3	1
FOR HIGH ACS	3	3	5	5	4
FOR LOW ACS	3	4	5	4	3
GOOD WRITING ASSETS	4	2	4	5	2
FUN TO TEACH	3	3	5	5	3
FUN TO LEARN	4	4	5	4	3
FIELD TRIP POTENTIAL	4	1	1	4	1
Weighted Ratings	3.6	196.9	240.7	266.2	167.8
% of Max Possible **		64.6%	78.9%	87.3%	55.0%

*Weights and ratings are on a one-to-five scale. Five high, one low.

Weights are added by multiplying the average of weights by the total of the ratings.

** Percentage rating is against maximum total possible rating.

The other kind is a memory-resident program, such as Side Kick or Ready, which you can access while you are using your speadsheet or word processor. It will let you make notes, bring back the notes you wrote to yourself at the beginning of the day, or show your schedule if you entered it on a file earlier. It sure beats writing notes to yourself on the blackboard.

The units I described have some implications for classroom management. In my classroom students are frequently working in small groups, and this gives me the time to work with an individual student at the keyboard. I also sometimes send one student off to the computer in the corner, while everyone else is involved in a discussion, though I might pick the student who always knows what I have just said even though he appears to be in outer space. If student use during class time doesn't distract you, it won't distract anyone else. To sum up, I have given several examples of ways I have used microcomputers which exemplify my own style and philosophy of teaching. I have found that my teaching has been changed by my use of a computer, I am equally sure that I have not been pushed where I didn't want to go.

During the first part of my sabbatical I looked for others to give me the answers to that which I wanted to learn. While there were and are people who know much more than I. my search was in vain. In discussing this with others I decided that there were no set answers to the questions about how best to use computers in the humanities. The answer for me was to dig in and try some of my ideas with real children and real teachers. When we do this we may squirm a little, but ultimately we can delight in what we find and what lies ahead.

TO SUPPORT THE LEARNER:

A COLLECTION OF ESSAYS ON THE

APPLICATIONS OF TECHNOLOGY IN EDUCATION.

How do Schools Organize to Use Technology?

Program Officer
Frank B. Withrow, Ph.D.
Team Leader
Technology Applications Group

Programs for the Improvement of Education

Office of Educational Research and Improvement
United States Department of Education
1989

SYNTHESIS: ORGANIZING EFFECTIVE TECHNOLOGY USE

by Jean Sanders

The superintendents, principals, and teachers who do not make decisions about using technology to improve instruction, must, as Peter Drucker warns, pay the costs of not using it. The task of the school manager who has to make complex judgments relatively soon is not simple. Mojkowski depicts a "maelstrom of education renewal" in which school managers find themselves trying with one hand to steer a steady course for their schools and with the other to initiate and sustain much needed improvements. Where there is limited and unreliable data, these risks are heightened. To minimize the risk, the administrator relies on professional judgement and proposes imaginative solutions to management situations. The skilled manager must seek pertinent data, and weigh their alternatives and consequences.

At the same time, the skilled manager must help the organization anticipate and address issues that have been overlooked as new risks are assumed for the future. Sometimes the cost of a risk -- in energy, resources, time, and effort -- is a necessary management expense, like a higher insurance premium. But we also need to recognize that schools are not set up to budget for long-range needs; nor do they have venture capital. That means part of the risk must be absorbed by other educational agencies as well -- usually the State and Federal government. It is towards this myriad of tasks and the necessary risk-taking or innovation that this chapter is aimed.

Technology supplies useful tools -- not just for transmitting and storing of information, but for processing information and generating new knowledge. In particular, systems of technology offer a perspective on the manager's task that facilitates learning. Yet technology by itself is not enough; it must be managed to be effective. Many educational managers (i.e., administrators) lack experience with technology and have difficulty making selection decisions on how to use it. Conventional means of schooling, even when extended by technology, may not be enough to produce educational quality we will need in the 21st century. We need to address what may be considered the "framework issues" -- the ones that dictate how day-to-day problems are solved, how policy and procedures are established, and how resources are allocated.

The critical issue on implementing technology includes the impact of technology on our measures of productivity and the changes needed to use electronic tools wisely. We know from the effective schools research that we need to improve our organizational and educational effectiveness; that is, how we conduct the business of learning. We recognize that much of what we expect from educational technology, such as helping improve the instruction in basic skills, will require new forms of school and classroom organization, new patterns of resource use, and new roles for teachers and administrators. Scores of research reports and reform studies recommend other changes in decisionmaking structures, in restructuring and reorganizing, and in delivering educational services.

How schools use technology for individual and organizational improvement will depend on the visions of school leaders, on the potential they see. Such critical issues as procuring and allocating resources, finding sufficient staff time, administering a fair and productive school program, along with quality assurance and evaluation components, are highlighted in this chapter.

In the first article, Rhodes reminds us that man the symbol-maker is also man the tool-user. Teachers are primary technological tool-users; consequently, we must ask how technology will assist them in their task. Rhodes also encourages us to reexamine the functions of the schoolhouse itself -- its means and the ends. In an effective school program, he argues, organizational models and mechanisms support innovations and complement individual creativity.

Managing technology initiatives must also take into account the organization of schools and use of staff. Koontz, in the Fairfax County School Department, has observed the day-to-day situations teachers and students face as they interact with technology and how change is part of the daily reality in schools. A Professional Development Center enables schools to be more productive. As receiver of one of the United States Department of Education Secretary's discretionary grants in basic skills (1984-1986), Fairfax has begun to develop support structures. Fairfax and eleven other sites began to study how to organize schedules, staffing patterns, the allocation of human and other instructional resources, and the learning environment to make better use to technology. In short, on establishing the processes that will be used to improve educational practice. These pilots have also examined new kinds of educational delivery and the new skills expected of students as they undertake further learning -- the skills for "learning to learn." Significantly, each of the curriculum areas cited as part of the Federal project in Fairfax County highlights the potential of the computer as a powerful tool to enhance learning.

We know that technology creates the need to make substantial changes in the ways schools are organized and staffed. Lavin asks: "Do we have a rational process for predicting short and long term changes? Do we have accounting mechanisms and methods (conventions and algorithms) that permit us to measure cost-effectiveness against student learning?" The commitments managers make to technology resources will affect all other resources and, if hastily made, may even impede productivity and performance. Policies and school structures now in place may hamper both teaching and the use of technology. Viewing technology as an added value to the educational delivery process, suggests a framework of questions from which to view the costs and benefits of these resources when examining what schools already do and ways of combining them with outcomes that managers are able to identify.

How will education benefit from technology advancements? The answer to this question depends on how we measure productivity and learning. Decisions about financing technology require us to consider its cost-effectiveness and policy issues, including alternative allocation of resources. Gains in productivity are hard to realize and even harder to place a value on. Our models of accountability for future goals may require a very different structure for schooling, including policies, environments, curricula, and methods. Accounting for these intended benefits and the "value added" will require sophisticated procedures and comparisons both for the short and long term.

As we plan to use technology in schools, there are also questions of copyright. Photocopies made it easy to copy printed matter; electronic technology makes it possible to copy and re-copy computer or video programs. Gilliland argues that we all should confront the ethics of pirating electronic copies. It is certainly an issue students will face as they leave our schools. Not only should we reexamine the place of ethics in our curriculum; school policies should mirror the expectations for honesty placed upon students.

The final article, by Karen Billings, is on evaluation of technology programs. She addresses the key issues associated with monitoring these efforts and modifying or fine-tuning the programs in light of evaluation data. If technology implementation occurs without well thought-out evaluation designs that are in place at the onset, it will not be possible to answer the issues of cost effectiveness. "Evaluation" is a word which often involves fear and distrust. Karen Billings suggests an approach that can make evaluation a trusted friend of administrators and teachers alike. Her suggested procedures will also help us to describe replicable programs that use microcomputers and related learning technologies to enhance instruction in the classroom, computer lab, and other educational settings.

INTRODUCING TECHNOLOGY TO SCHOOLS:

IS THE OPERATION A SUCCESS IF THE DOCTOR DIES?

by Lewis A Rhodes

America has had no problem introducing technology to schools. Keeping it here has been a different matter. For half a century major technologies already accepted by the larger society, such as radio, film, and television, have been "offered" to education with the financial help of foundations, industry, and government, accompanied by the inspirational support of dedicated educators from within.

Research tells us that none of this has made a difference. Now as computers and other information technologies line up at the school house door, education has a choice. We can once more take the blame for not being innovative, for not wanting to change, for not caring enough to offer children the very best -- or we can learn from past experiences.

This article is offered to further the latter choice. It assumes that two factors usually limit our ability to learn from the past. A focus on "blaming" instead of "understanding." where we retroactively seek simplistic causal relations in complex situations and therefore fail to see all relevant data; and second, we limit our reflective learning by a too-narrow definition of the situation we're studying. This article like others in this publication, uses a case study approach. However, the case presented is an alternative view of what has happened (and not happened) with technology in schools over the past 30 years. Six principles will be presented for introducing technology as a tool for improvement rather than as an improvement itself, as part of a process that can eventually lead to more effective education and educators.

The following alternative historical view of schools and technology derives from the author's direct experiences as a participant-observer. It seeks to share a growing self-awareness that includes a viewpoint seldom given much credibility in discussions of technology in education -- that of the tool-user.

This lack has been a major blind-spot for our generation. We felt we needed to understand unfamiliar technologies before we could use them. Therefore we focused more on the tool than the user. That perspective has meant that today education is one of the few institutions where tools are provided for the clients instead of the workers. Let's look at why this happened, and also why it was, and still is, a more pervasive condition in education than in the rest of society.

LOOKING BACK

Most classroom and school decision-makers for the past 30 years had not grown-up with the new technologies being offered to them. We acted like first generation tool-users have always acted, using (in McLuhan's words) a "rear-view mirror approach" that resulted in old objectives being accomplished more effectively but few of the tool's new possibilities being used. What a first generation usually lacks is direct personal experience in solving problems with a tool. When elevators were invented, architects put them in three- to four-story buildings where, if one wanted to, the stairs still offered a reasonable alternative. The next generation "assumed" elevators instead of stairs, having grown up with them. This "assumption" of the technology carried with it an assumption of its potentials. Skyscrapers were born.

Without practitioners' direct personal experience and knowledge of its effectiveness to "pull" technology into schools, technology introduction has been a "push" process. As with other "innovations" technology projects seldom involved the tool-users in their design and operation.

Front-line practitioners have tended to feel that it is useless to substitute a new method for one which already works. They have found it easier to wait for "proof" from experts and specialists that technology really is more effective. In turn, information in the form of research results and model demonstration projects has been "pushed" onto education in the hope that it would serve as a substitute for decisionmaking at the local level.

Thus, the last half-century can be largely characterized as a first generation of tool-users, researchers, and technology specialists inadvertently maintaining a situation:

Where research results consistently reported "no significant difference" because nothing in the classroom or school was significantly different;

Where media and technology experts were limited to perfecting their particular tools almost as "ends" in themselves because of the few opportunities to look beyond the tools to what could be possible if (in Emerson's words) "you didn't care who (or what) gets the credit;" and

Where educators who did gain direct personal experience, and who were becoming aware of the possible "skyscrapers," were frustrated in their attempts to communicate with those who lacked their experience and interest. Thus, despite many examples that technology "worked" in individual schools or projects, the examples soon disappeared when the leader or staff left. The operation was a success, but the doctor died.

The discussion so far might well be seen as revisionist history designed to get education off the hook for not accepting technology -- except for one factor. The rest of society, also part of the same first generation, has been able to gain personal experience and incorporate it into more effective goal accomplishment in a much shorter time. What has been different about education?

First, its context. As a social institution, society plays an influential role in the "what" and "how" of schooling. In the case of technology this has been a schizophrenic factor. On the one hand it has been the larger society's overwhelming acceptance of telecommunictions and computer tools that has placed pressure on schools to introduce them. On the other, individual parents will resist anything they perceive as interfering with their own, experience-derived model of schooling, i.e. they don't want anything that gets between a teacher and a student for too long.

But external perceptions haven't been the only factors keeping education behind other institutions in accepting technology. Two others may be more significant.

The first has been our inability to see these new tools within the context of the tool-user whose daily decisions create the experience called "schooling." Technology hasn't been the only area of change where the invisibility of the educator as worker and decisionmaker has produced a partial equation that can't be solved. But here it is most critical because tools, while they have uses, are relatively value- and goal-free. They make a difference only when used by someone committed to making a difference.

The final difference between tool use in education and the rest of society has to do with institutional orientation. Technology has been accepted in business, industry, health care, and other social services because these are outcome-oriented. Tools that make it easier to achieve outcomes fit because the environments are managed for that express purposes. It is no secret, as the literature on outcomes-based schooling has pointed out, that schools aren't managed that way. We treat our manageable variables such as time (period, semesters, school years) and space (classrooms, buildings) as constants; desired outcomes (student learning) are treated as variables. Little wonder, then, that tools that can help educators achieve outcomes are hard to maintain in schools once they are introduced.

LOOKING BACK THROUGH A DIFFERENT LENS

Nothing above is meant to imply that there has been no effective use of technology in education for the past 30 years. There has, but we often didn't have the perspective to allow us to recognize it.

What might we have seen if we had the benefit of the organizational and educational research that in recent years has illuminated our understanding of the human side of work in organizations? Just as scientific research has progressively uncovered the nature of visible matter by moving through layers -- from wood to molecules, to atoms, to electrons -- so has recent social research begun to look beneath the layers of organizations. In education, for example, research has moved from consideration of visible schooling and teaching processes to the human behaviors and acts that make up those processes; then to the nature of the individual decisions behind that behavior, and, on to the psychological processes that underlie those decisions.

One result of this shift in perspective is a view of organizations as groups of purposeful, psychological beings linked temporarily together to accomplish a mutual goals. With two purposeful processes -- one organizational and one psychological -- operating in tandem, any tool has to contribute to the individual worker's sense of purpose and accomplishment, as well as to meeting an organizational purpose. That is why treating practitioners as "gatekeepers" to change, or "teacher-proofing" materials, has helped keep technology out of the school house until now.

What might we have seen had we looked at the use of technology in schools with such a perspective?

We might have seen that the "process" each new technology required for its introduction was an important "product" contributing to its success, and not something to be ended once intitial implementation was thought complete. These processs typically involved bringing people together to plan, letting them question the unquestioned organizational regularities, helping them prolem-solve when things didn't work, giving them some influence over their own work environments, and having them see tangible results.

We *might* also have seen that outcomes are important to individuals, whether the school is managed that way or not. For example, research is documenting that in effective schools missions and vision help individuals orient their decisions toward mutual outcomes. The result is an increased sense of meaning and satisfaction. With technology too, it is many times the promised outcome that justifies the personal cost of the means to achieve it. Thus, we could have seen that technology implementation wasn't being blocked by the cost of hardware or software, but by people-wear -- the personal cost to busy people in terms of the time and energy required to rethink what they do, how they do it, and (because of the effects of the answers to those two questions on established relationships) why they do it. Most of us are unwilling to invest considerable time and energy unless the end makes it worthwhile.

Further, we might have seen that tools are not always purchased because their comparative effectiveness is proven, but because we see that the tool can be applied to barriers to our own satisfaction. The home offers an analogy. One doesn't buy a dishwasher, microwave, or food processor for the first time because of research. All one knows are the problems inherent in a task which will be addressed by the new tool. The problem and the promise (the advertising hype helps here) are enough to get one started. Training is seldom a prerequisite for buying the tool. We learn by using it, making mistakes, and trying again.

Finally, we might have seen more clearly how our training and dissemination efforts were oriented in the wrong direction. The traditional "top-down" approach makes little sense when one acknowledges how human beings learn a new skill or procedure that must substitute for an accustomed one. This happens through trial and error, in response to real needs, with continuing feedback and support. It requires grassroots networks and regular ways to exchange experiences.

LOOKING AHEAD -- THE THREE R'S OF STRATEGIC TECHNOLOGY USE

With the benefit of this hindsight, we can return to the topic of introducing technology to schools. The new information technologies we are concerned about may need little introduction. School practitioners probably have met them in one form or the other and may have examples in their buildings, classrooms, or homes. What must be introduced is the idea of technologies as tools for both personal and organizational effectiveness. This introduction process requires both learning and unlearning; the focus must be shifted from what the technology _is_ or _does_, to wnat it allows people to _do_.

To introduce technology into a school in this way requires a systematic exploration of technology's potentials in daily practice -- a discovery process that will allow school staffs to connect their firsthand understanding of the barriers to effective instruction and learning with the potentials and possibilities offered by new tools. What the participants discover in this process is the strategic role technology plays in increasing school and staff effectiveness -- helping to solve problems, connect to resources, and facilitate trade-offs. Although this process focuses on the staff as tool-users, the ultimate beneficiary is the student, because learning to use a tool for your own use provides a most effective way to understand how others might do the same.

Three principles underlie this approach to introducing and using technology. Technology use should be *Required*, *Reflective* and *Regular*. These three R's, are derived from observations of schools beginning to discover the potentials of technolgies and from research in both school effectiveness and adult learning. They suggest that school staffs have to be conscious agents of their own learning, that this learning must emerge from the exploration of new ideas in the context of practice, and that schools have the obligation to provide those opportunities.

1. REQUIRED

The Building as the Framework of Discovery. Only individuals can discover and learn, but they need the opportunities and support to do it. That process of support must be managed and the building is the most effective unit to handle it. On-the-job, trial-and-error learning is too risky without understanding and supportive leadership. The building also provides a pool of experiences for exchange and analysis as well as peer support.

This technology discovery process can easily be tied into the building-based school improvement and school effectiveness projects underway in schools today. If no such process exists, but if there is concern in the district about the use of technology, then "technology" itself can be used as the catalyst to get a school-based improvement process underway.

Recognize That You're in it for the Long Haul. As far as society's concerned, the technology "revolution" is not a soon-to-disappear fad. We're in the first stage of an evolution. This can be accelerated by what we learn and do today, but it can't be stopped.

The process of problem-solving with technology must be seen as a continuing activity -- a way to continue to explore, learn, apply the learnings, and discover again as the uses of technology expand the limits of the "possible." Support for this continuing process in the building takes the form of regular opportunities to focus on problems, exchange what's being learned about dealing with them, and plan new strategies. This periodic reflection must be documented so that what is being learned can be shared with others as well as built upon in future cycles. Moreover, this documentation can provide the substance to feed a variety of networks among buildings and districts.

"Expect" Use of Tools. When telephones and copy machines are placed in school buildings, there is an expectation (but not actually a requirment) that they will be used If the organization providing the tools meets its obligation to make them accessible, then objectives gradually increase to accomodate the expectation that the tool will be used. For example, an "unreasonable" request for 25 copies of a document in the days of carbon paper, may be easily accommodated today.

2. REFLECTIVE

Assume You Don't Know. Assuming that you don't know the best ways to use technologies may seem easy because we really don't. Yet some people perceive a risk in admitting it because we, or they, think they "should" know. Don't let such persons or presuppositions prevail. Even though one may know more about technical operations, or what research says should be possible, the focus of the discovery process is the effective use of these new tools within the dynamic environment of the classroom and school. We all start even in this process.

The acknowledgement of "not knowing" is the key to an effective discovery process. It is the motivator that drives continuing participation. Without it, the process becomes a training exercise designed to have people "discover" what others want them to learn. Instead, in this process participants are seeking what they want to learn -- how to be more effective.

"Not knowing" also can produce valuable consequences. Schools are finding that it opens up closed communiction channels. For example, principals traditionally are supposed to know more than teachers, teachers more than students, and district office specialists more than any of them. This assumed hierarchy of knowledge can restrict the effective exchange of information. Because we're all first-generation users, technology can provide a safe domain where it's okay to say "I don't know." When they do this, principals develop new collegial relationships with their teachers. Teachers and students approach learning tasks as peers rather than as adversaries.

A second consequence of this organized exploration is that technology serves as a catalyst for raising questions about the assumed regularities and "supposed-to's" of running schools. "Why do we...?/why don't we...?" questions appear as staffs become aware of many no-longer valid reasons for operating as they do.

Focus on Wants. This principle is an important prerequisite for finding helpful tools among today's technologies. The question that will lead us to those uses is, "how can we accomplish...purpose?" But before we can ask that question we must know what we really want to do (if it were possible). and what gets in the way of doing it now.

As human beings, we would face constant frustration if we didn't limit our desired "ends" by what we think is possible. This becomes a handicap, however, when means are available to extend the "possible" but we no longer seek the "impossible" ends. Thus we must first expand our sense that we can do what we really want to do.

A way to begin is to have each school staff member aks: "If there were enough ________(fill in the missing resource) and anything were possible, what would I do to be most effective? What role(s) would I play in terms of students? How would I function?" The purpose of these and other questions is to create cognitive dissonance -- to help staff identify the gaps between what they do each day and more effective and satisfying roles. If this isn't done, there is a good chance that any technology use will just extend current curriculum, organizational and instructional procedures.

These questions about what a staff would want to be doing, however, provide only part of the information needed to search for helpful tools. We should assist staff to differentiate between the process of teaching and the process of overcoming the barriers to effective teaching. Some of the barriers may include lack of sufficient information about individual students, lack of control over time or space, lack of appropriate resources, and lack of effective procedures for certain situations. It is important for a staff to see how much time is devoted each day to overcoming these barriers and then identify which have the greatest negative impact across the school.

These data about the problems a school would most like to eliminate, along with the data on "wanted" roles and functions, provide the conditions for identifying trade-offs. What regularities, e.g., class size, length of school period/day/year, etc. , are we willing to trade for something we really want?

Seeing Yourself as a Tool User. One additional element is necessary for the reflective planning process to work -- a personal awareness of one's self as a tool-user.

Most of us are relatively unaware of how and why we use tools in our lives outside education. Discovering this, and then comparing it to our behavior within schools can, once more, create helpful cognitive dissonance that can lead to change.

For example, staff can conduct the following exercises:

> Discuss how you feel when you read the following on the top of a washroom hand dryer:
>
> TO SERVE YOU BETTER
>
> We've installed pollution-free hand dryers to protect you from the hazards of diseases which may be transmitted by towel litter.
>
> *Dries Hands More Thoroughly
> *Prevents Chapping
> *Keeps Washroom Free of Towel Waste

How do the purposes and objectives cited for the technology relate to their needs and purposes for using it?

Look at tools that were new to your parents or grandparents (such as telephones, dishwashers, television) and compare their "first generation" uses with your own.

Discuss the differences between a tool's uses and its consequences (the effect of its uses on roles, relationships, etc.). For instance, the Reformation was one consequence of the printing press, the shopping center is a consequence of the automobile. (It is important for a staff to find out that they must and can anticipate and plan for consequences as well as uses.)

Look at tools that extend your physical capabilities (e.g., cars), and his sense (e.g., telephones, television). Then discuss the computer as a way to extend the mind (e.g., its capability to store access, and process information). What implications does this have for your school?

3. REGULAR

Model the Process. What an individual organization does on a regular basis usually serves as a good indicator of its values and beliefs. If a district is to expect technology use, it should serve as an effective model. This is important because we tend to learn new approaches from personal experiences. That is, we are more likely to teach as we were taught, parent as we were parented, and manage as we were managed.

Therefore, in managing the technology discovery process, a district should use technology strategically to solve its management problems. For example, it might use electronic conferencing -- by computer or telephone -- to link some staff (e.g., history teachers, early elementary teachers) with peers in other buildings or districts. When you begin to search for relevant applications of specific technologies, access to data bases can simplify the tasks. You might also consider trade-offs such as bringing a noted speaker to your entire staff via audio-telelecture instead of sending only one or two to a meeting where he or she is speaking.

And once again, it's important any time technology is used to support a district or building's own processes that staff have an opportunity to reflect on the experience. What was gained, lost? What are the implications for similar uses in instruction?

CONCLUSION

Although the processes suggested above may seem to have little to do with the way we normally think of educational technology, they address the issues that have hampered effective integration of technology for the past three decades. They allow the workers in our schools, whose decisions most effect the quality of our product, to develop the awareness necessary to answer the question "How can we be more effective?"

Through strategic processes like this, technology can become a tool that can:

- <u>empower</u> individuals increasingly frustrated by their lack of control over their own job destinies;
- <u>connect</u> peers for problem-solving exchanges;
- provide <u>access</u> to information and other resources at the point and time they are needed; and
- facilitate <u>trade-offs</u> of the nonhuman variables in schooling to make better use of the unique attributes of the human beings.

Once "introduced" in this role, technology will stay awhile and, importantly, will pull along with it the effective applications to enhance student learning that are the common interest of us all.

THE COMPUTER TEACHER AND THE COPYRIGHT LAW

by Kay Gilliland

Altair, the first microcomputer, came in a box. The front had switches and lights; you had to put it together yourself, and when you got it running you had to program it in machine language; applications software for the hobbyist was nonexistent. The date was 1975. Microcomputers began to arrive in the schools in about 1978. Suddenly educators where faced not only with revolutionary new tools and ways to teach, but with new concerns of conscience to be considered.

For example, students are greatly tempted by the ease and speed with which computer software can be copied. The resulting program is as perfect as the original, and the theft cannot be detected by examining the software. Sometimes students do not even realize they have done something wrong. At present, less than a dozen of the 16,000 United States school districts have a notable computer ethics program (National Center for Computer Crime Data, 1986). The schools can make a major contribution by teaching students the history of our intellectual property laws, their meaning and importance, and the situations in which they apply.

The history of intellectual property protection dates back to Roman times. Roman texts make reference to individuals as authors and to terms of payment for intellectual contributions. Plagiarism was clearly considered unethical, but no specific laws have been found (Office of Technology Assessment, 1986). In the Middle Ages, when monks copied manuscripts by hand and minstrels transmitted their creative expressions orally, there was little need for protection. The printing press made for radical change. Publishers (i.e., printers) were able to make multiple copies for sale and they, not writers, reaped the monetary benefits. Writers with patrons continued to live on handouts, writers from wealthy families continued to live on inheritances, and those with neither continued to starve.

Finally, the realization dawned that creative works would not flourish unless those who created them were compensated. The English Parliament passed the Statute of Anne in 1709, the first "modern" copyright law; the framers of the United States Constitution built upon this foundation. They believed that the creation and spread of information was essential to the new nation, and they believed in the power of knowledge to effect social change. On September 5, 1787, there was unanimous approval to adopt a Constitutional clause empowering Congress

> "To Promote the Progress of Sciences and Useful Arts by securing for limited Times to Authors and Inventors the Exclusive Right to their respective Writings and Discoveries (Article I, Section 8)."

Intellectual property law was intended to serve the goals of education and learning. The first Federal Copyright Act (1790) reaffirmed that these statutory rights were granted to fulfill a public policy purpose. The 1909 Copyright Act reiterates that the rights are secured

> "on the ground that the welfare of the public will be served... Not primarily for the benefit of the author, but primarily for the benefit of the public, such rights are given."

The intent of the 1976 Copyright Act and the 1980 and 1984 Amendments regarding computers and chips continued this policy.

REVIEW OF PROPERTY TYPES

There are three kinds of property: real, private, and intellectual. Intellectual property can be distinguished from other forms of property in that it is the intangible form or expression of an intellectual, scientific, or artistic creation. Intellectual property law secures ownership in the expression embodied in things. A particular book of poetry is tangible, private property and belongs to the purchaser, but the copyright owner retains the rights to the form of expression of the ideas within all copies of the book. The purchaser of a Brand X video cassette recorder owns the set, but the copyright owner retains the rights to the circuit design for all Brand X VCRs. The word "work" is a general term referring to any intellectual creation, and is used to distinguish particular copies from what is protected by copyright.

Property is by definition exclusive, and the boundaries of property rights are agreed upon by convention. Policymakers must choose why and where they are established. United States policymakers have tried to set the boundaries to promote the spread of knowledge through publication, production, and distribution of the expression of ideas. Boundaries too broad impede the very progress they are intended to promote; boundaries too narrown diminish the incentive to create -- again impeding progress. To "Promote the Progress of Science and Useful Arts," policymakers have constantly striven to strike a balance between what belongs to the creator and what belongs in the public domain. The 1980 Amendment to Section 101 of the Copyright Act regarding computers has been interpreted by the courts in a very comprehensive fashion: any medium, any form, any computer (Office of Technology Assessment).

The full impact of the new technologies on the intellectual property system will not become apparent for some time. Changes are occurring constantly, and in some ways the new information and communication technologies do not fit neatly within the existing framework of the law. Congress has been advised to start now to systematically collect data about, and enhance our understanding of, information needs, users, producers, and information-based products and services (Office of Technology and Assessment, 1986). In the meantime, educators will do well to follow both the letter and the spirit of current law.

ELECTRONICS AND COPYRIGHT LAWS

Electronics blurs the boundaries; works of art, fact, and function intermingle. The results and the methods of achievement then become one, leading to protection of the ideas and knowledge, rather than just their expression. This might severely restrict the progress of knowledge and thus fail to serve the public good. Copyright is not a patent. Patent law requires that the invention be an advance over "prior art," that the patent be conferred for a shorter time and the invention be shown to be unique. Copyright was not intended to protect functional information; it protects the recipe for the cake from being copied but does not prevent the cake from being baked. However, with the interchangeability of form represented by computer software, the computer program really can bake the cake by hooking up the appropriate peripherals!

The first computer program was accepted for copyright in 1964 even though the Copyright Act of 1909 did not anticipate computer technology. The Act was amended in 1976 (by the Copyright Revision Act which took effect in 1978), further amended two years later, and amended once again on November 8, 1984. The courts generally have interpreted these laws broadly.

The holder of a copyrighted original expression has five exclusive rights, any one of which may be sold or transferred independently: (1) to reproduce the work in copies, excluding fair use and an archival copy; (2) to prepare derivative works based on the work; (3) to distribute copies for sale, lease, or even for free; (4) to perform the work publicly; and (5) to display the work publicly.

The exclusive right to reproduce the work in copies means just that. It does not matter how ephemeral the copy; a RAM copy that can be wiped out in a few minutes after the brief lesson is over, or a copy on a diskette that can be handed to the next person. It does not matter how the program is loaded into the computer: by hand into four machines or by a networking system into fifteen machines. Those are still copies.

Only the copyright owner may allow someone else to make copies by making an assignment of the rights, a license to the rights, or a sale of the rights. The owner may decide to transfer all of the rights or only a portion of them, because copyright is divisible. An owner may choose to allow multiple loading of the software but choose not to allow networking. She may choose to license a site to copy software or she may limit the use of the purchased copy to one machine at a time (Bunnin, 1985).

"Fair use" is provided for under Section 107 of the Copyright Act. For purposes such as criticism, comment, review, news reporting, teaching, and research, use of the copyrighted material is not an infringement. Things to be considered in making this determination include the purpose and character of use, the nonprofit nature of the use; the nature of the work itself; the amount and substantiality of the portion used; and the effect upon the potential market for, or value of, the copyrighted work (Laurie, 1985). Direct classroom use of an entire program, even though it would certainly be for educational puposes, would not seem to fit the definition of "fair use." It is not an infringement of copyright to make a copy for archival purposes or for the purposes of adapting the software for use on another type of machine.

Permission to make a back-up copy was made a part of P.L. 96-517 because of the special risk of destruction of a disk either by electrical or mechanical means. This archival copy may not be used as a second copy nor expected to replace a copy worn out through normal use. Features may be added to the program and to the documentation, but these are not considered "original expressions" and may not be sold (Hollman, 1985). The program may be adapted from one language to another so long as: (1) the adaptation is made for use in a machine owned by the pruchaser, and (2) the adaptation is done only in order for the purchaser to use the program. It must not be vended or made to compete with sale of the original.

COPYRIGHT IMPLICATIONS FOR EDUCATORS

You can't copyright an idea, but you can copyright its expression. The copyright, according to the 1976 Copyright Act, is in force the minute the work is a reality. When the author makes a copy of the work, it must bear a notice of copyright (the symbol or word, the year of first publication, and the name of the owner):

c 1986 Kay Gilliland
Copr. 1986 Kay Gilliland
Copyright 1986 Kay Gilliland

The first method is preferable because it is accepted worldwide wherever copyright is recognized. The latter two are valid in the United States. If the work is published in Latin America, it must also say, "All right reserved." Errors and omissions weaken the protection against unauthorized copying. Registration with the Federal Copyright Office is not a prerequisite to copyright protection; however, a copyright owner cannot file any infringement action unless and until registration is effective.

There is little doubt that teachers and other educators become models for students in their decisions concerning ethical issues. If we do not follow the law, how can we expect our students to do so? We must find ways to serve our students' coginitive needs without destroying ourselves ethically.

Software that is used sporadically by individual students can be placed in a library and checked out in the same way print materials are handled at schools. Extra care and education must be provided to avoid the library's becoming another source of copies that contravene copyright law.

The solution with regard to purchase is to deal with the software suppliers who will meet teachers halfway. Copyright is **divisible**, and therefore a software company can allow multiple loading, networking, and site licensing if it so chooses. Teachers must operate under the principle of informed consent, notifying the company of their intentions before purchase. One suggestion is to ask for the software company's policy on whatever practice is needed for a particular classroom. Another equally valid method is to describe in writing, on the purchase order, exactly how the piece of software will be used.

If the company chooses not to sell under those circumstances, teachers can do their best to find another software company. New and exciting programs are being written every day -- teachers need not be dependent on a company that does not take into consideration their legitimate needs. Most of all, teachers must not abdicate their responsibility to follow the law. The Constitutional mandate empowers Congress to grant authors and inventors the exclusive right to their "Writings and Discoveries" for limited times "in order to Promote the Progress of Science Useful Arts." Far be it for teachers to fail to heed this provision which has worked to the benefit of society since our Constitution was written!

RAISING AWARENESS OF COPYRIGHT ISSUES

Role-playing provides one way for teachers and students to clarify their thinking on important issues. EQUALS, a staff development program at the Lawrence Hall of Science, University of California, Berkeley, has used vignettes with over 700 participants -- administrators, parents, teachers, lawyers, school board members, and legislators. Many of the teachers have used the vignettes with their classes. Participants expressed surprise at the complexity of the issues and agreed that the subjects should be further explored by students and adults.

To do this activity, give a group of four participants an envelope containing name tags, a situation to discuss, and a slip of paper describing one character's view of the problems. It is important for participants to delineate each role clearly and to distinguish between the times when they are role-playing and when they are expressing their own opinions. Participants begin by reading the situation and introducing themselves as the character they are to play and telling about the character's point of view. Then each discusses the problem from the point of view of the person he or she represents. When the role-playing has been completed, the participants take off their name tags, become "themselves" again, and talk about the problem from their own perspective, attempting to reach a creative solution.

When all groups have finished, a report from each small group is given to the whole group, explaining its scenario and what happened when the group was acting as well as what was decided when people were expressing their personal real opinions. Teachers who used the situations in classrooms suggested that it was often easier to give all the groups the same question, and even take a second day to switch roles, enabling different students to play different roles. It was also helpful, when discussing on their own, for participants to have thought about the problem over a period of time.

The activity below is one of four role-playing examples from **Off and Running: The Computer Offline Activities Book**. Four more have been published in the **Proceedings of the Sixth Annual Conference on Microcomputers in Education**. After a few sessions, students can being to make up their own scenarios addressing a wide range of computer related ethical situations.

After participating in a role playing session of this sort, one teacher wrote,

> "At what budget level can districts (schools,
> teachers) afford to maintain an ethical stand?
> At what cost do we abandon it?"

When students know the history of our intellectual property laws, have been involved in class discussions of their meaning and importance, and have tried out various roles in relation to the problems involved, they will be better-prepared to make wise choices for themselves, both as students and as adults.

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EVALUATING A SCHOOL'S TECHNOLOGY PROGRAM

by Karen Billings

When new technologies are brought into schools, new educational programs are often implemented along with them. Teachers of mathematics, social studies, language arts, and science have seen many such programs come and go in their respective fields. Mathematics teachers, for example, have in the last two decades, experienced the "new math" program, a metric movement, the lab/manipulative approach, a "back-to-basics" era, an emphasis on problem solving skills, and most recently, the use of calculators and computers. Other content areas have seen changes as well, with assistance from textbook publishers, testing agencies, state education departments, Federal agencies, colleges and universities, and their professional organizations.

When teachers and students have sufficient access to the technologies, whether computer, communication, or video-based, this access affects the content and teaching methods of the courses of study. Depending upon the evolution oftechnology and the creativity of the instructional developer, one or more aspects of an existing program will change: the curricular objectives, instructional resources, or teaching methods. In some cases, totally new programs will develop because there is new content to teach, as with the computer literacy or computer science.

The teachers and administrators in our nation's schools implement these new or revised educational programs because, as educators, they want to improve student learning. In some schools, the programs will be implemented under the best of conditions, with creative and competent teachers, abundant and appropriate resources, effective administrators, and a supportive local community. These programs seem destined to succeed. In other classrooms or schools the programs seem destined for failure. They are hastily planned by the program staff and then implemented by teachers who are not adequately trained or supported by their administors. Program staff are asked to work with inadequate resources and students are not given sufficient access to the technology.

All programs need review and monitoring, whether they were implemented under the best or the worst of conditions. At the end of the first year, it is usually clear to the teachers and the program planners that their program has either been a success or that it has had significant problems. Either way, those who gathered information during the first part of the implementation can offer a greater chance of success to the program the next year.

The purpose of this paper is to first review the need for and purpose of evaluating technology programs in the schools, and then to describe an evaluation procedure that can work in classrooms today and to produce better classroom programs tomorrow.

THE NEED FOR EVALUATION

Teachers want to review any technology-related instruction to see what needs to be changed from one semester to the next. Building principals and computer coordinators want to review all of their programs periodically to see if any goals and objectives should be changed, if any teacher or staff training is needed and what kind, if instructional materials are appropriate , and if students are learning what is expected. District personnel may want to be able to share evaluations with their communtities or report to their school boards. Last but not least, many program evaluations occur simply because the funding agencies re .est them.

In fact, any educational program, technology-based or not, should include an evaluation phase so that information can be gathered and used in the next stage of planning. If evaluation is carried out well, will help improvethe technology program can improve from year to year. The progam staff should gather information that is useful in revising the program, as well as information of interest to the community and other interested parties.

THE PURPOSE OF THE PROCESS

An evaluation process needs both procedures and tools so that educators can gather and use information about their technology program. There are two objectives of an evaluation process:

1. to gather information about the major components of the program; and

2. to use the information to develop conclusions and recommendations regarding the components of the program.

If a school's technology program is at a very early stage of development, the evaluation process will help educators react to a program plan or any newly developed goals and objectives. Programs that been underway for several years and have the components (courses, teachers, computer or video-based hardware, software, and other instructional materials) in place. In such cases, an evaluation process can be used to examine how well the components are working and what, if anything, should be changed.

While all evaluations have a set of steps in common, the process described in this paper takes account of the unique characteristics of a technology program. The process assumes that the technology-related goals and objectives change more often than those in the traditional content areas. And while the public is interested in the results of any educational program, there seems to be more urgency to review the results of technology use.

The process has three major steps: planning the evaluation process, gathering the information, and using the information. The rest of this paper describes each of these steps, which can be adapted and used by the readers.

PLANNING THE PROCESS

In planning any evaluation process, it is helpful to remember that it is an evaluation process and not a research project. If the program is in its early stages, a formative evaluation is probably more appropriate than a summative one. The formative evaluation process allows program staff to gather information for themselves, so that they can review what worked well and what did not. Evaluation information can help the technology program move from being an experimental one to being a successful one. Then a summative evaluation can be done.

There will be concerns and questions about any evaluation process. Typical reactions are:

* Isn't it too early to evaluate our program? We just started it!

* Why do we need to evaluate our program at all? It seems to be doing O.K.!

* Will this information be used on teacher's performance reviews?

* Is evaluation worth the effort? Reports just sit on the shelf!

* Isn't evaluation just another word for pre-test and post-test scores? To get data, you end up focusing on situations that are easy to measure and unimportant.

Find out the concerns and assumptions of those involved in the evaluation. Their concerns need to be dealt with adequately to get the cooperation of everyone. Make sure that everyone understands the purpose of the evaluation and that anyone who contributes to benefits from it.

WHAT WILL BE EVALUATED?

Before data can be collected, specific questions need to be developed about the different aspects of the technology program. Rather than ask questions about the program in general, ask questions about any of the program's components: e.g., the goals, objectives, staff development, instructional materials, and student accomplishments. Although this paper discusses the four components just mentioned, educators can review any one or more of these or additional components of the program.

Program Goals and Objectives. Program goals and objectives change as hardware costs decrease, as the access to computers increases, and as new programming languages and or software packages become available. Reviewing course or program goals and objectives offers information that helps the program staff decide which objectives should be changed, added, or deleted. Compare the objectives to the school's philosophy, community needs, the access to appropriate technology and instructional materials, and the teacher training.

Staff Training. Information needs to be gathered about all the staff in the technology program, not just the teachers. Constant feedback is needed on how staff are prepared. What has been successful in the past and what is needed in the future? How does the teacher training in traditional areas compare to the training in technology-related areas?

Instructional Materials. School personnel select and use computer or video-based hardware, software, and print/nonprint materials for use with students. What materials get used and how satisfactory are they? How well do they support the objectives of the program? What new materials are needed for next year?

Student Accomplishments. Teachers and students want the technology program to have a positive effect on students. What kinds of opportunities did students actually have while using each of the various technologies? What did students accomplish by using the materials that have been provided? What unexpected outcomes occurred as a result of using the technology?

WHAT ARE THE STEPS?

Because up-front planning pays off, it is importnat to understand the purpose of the evaluation and know what aspects of the program to evaluate. Before gathering any information, it is important to know if there are any standard or district procedures that must be followed. Think about the primary audience for the evaluation: What and how much do these people want to know? What kind of a report do they want? Lastly, what does the evaluation really mean to the school? How will the results be used?

GATHERING THE INFORMATION

After the planning process has been completed, gather the information. The steps are to first to develop the questions, then to select or design the tools, and finally to use the tools.

Developing the Questions. Questions should be formulated about any of the components where information is needed. If questions are relevant, people will want to help answer them and the report will be of interest to them. If questions are specific, responses are more easily obtained. Here are some examples of questions that have been made more specific.

Q: How is the computer education program going?

Better Q: Is the program fulfilling its goals or objectives?

Even Better Q: Does the program staff think that each goal or objective is being met? If so, how well was it met?
If not, why not?
How do the objectives that were actually implemented compare to those that were intended?

Selecting or Developing the Tools. After developing the evaluation questions, find or develop tools to help answer those questions. There are various tools to choose from, including questionnaires, observations, interviews, document reviews, and tests. Any tool can help gather information and responses to a question, but some tools are easier than others to administer; others are more labor-intensive but may give more detailed information.

There are few, if any, available tools yet that are useful for doing a formative evaluation of a technology program. A given program in any school will have unique goals and objectives for which no test items have been developed. However, tools that are process-related can be revised and used. Therefore, some educators are updating and using questionnaires or checklists that were actually developed years ago for reviewing teacher in-service programs or for selecting instructional materials, but giving them new life and a new role in the technology program.

Using the Tools. Once the tools are designed, it is simply a matter of scheduling the time periods for using them. Given the recent development of technology programs, many people are going to be will interested in finding out what really is being taught and how it is taught, and therefore in tools that help gather that data.

There are some limitations in the data collection, e.g., specific time periods when pre- and post-tests can be given or when teachers can be interviewed. Check to see if confidentiality is needed for responses to any forms or if permission is needed to review student records.

USING THE INFORMATION

Just as asking the right questions and developing the right tools are important to collecting the data, summarizing the information and developing recommendations are important to improvingthe technology program.

Summarizng the Information. The information has to be summarized well so the results can be presented well, either in writing or orally. The more structured the responses in the instruments, the more easily the responses will be to summarize. For example, responses with a numerical rating scale are already categorized and can easily be tallied and totaled. The responses can then be converted to percentages or graphed to give a quick glimpse of the information.

Making the recommendations. The information from a formative evaluation should be used to formulate the recommendations that will improve the program. Formulate the recommendations around the program components, just as the questions were. Within each of the components, try the following approach:

1. Discuss first those things that don't need to change because they are working well. Share the success stories of the technology program up front and acknowledge the attributes that seem to make something work.

2. Recommend next those things that would help reinforce or extend aspects of the technology program. Reviewing some of the success stories in the program will provide the basis to make

these recommendations.

3. Offer suggestions for revising or restructuring of the technology program. While it is easier to talk about the success stories than to fix a problem, the problems need to be reported and fixes need to be discussed.

Reporting the Information. The final step in the evaluation process is the report -- oral or written. Effective reporting of any information adds to its influence; poor reporting of the best of results is likely to make the results seem ineffective. Above all, the report needs to be delivered in time for decision-makers to study the conclusions and recommendations and to apply recommendations in their decisions.

The report will be shaped by the evaluation design, the extent of the technology program, the questions about the different components, and the audience of the report. Make it clear where the important information is located so the report can be understood quickly and easily. More people will use the results and the evaluation work will have been worthwhile.

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