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ABSTRACT

Five articles on computer use in higher education and three final papers presented at the Association for Educational Data Systems (AEDS) 1976 convention are included in this document. Implementing and evaluating computer technology in higher education is the subject of two articles, and another article describes instructional and administrative computing at a minority community college in a bilingual-bicultural setting. Application of a time sharing computer system to undergraduate business education and to teacher education is assessed in two papers. Computer use in a college-level high school biology course is outlined. Minicomputers for conducting real-time computer controlled experiments are evaluated. The document concludes with a case study of the publication of a course in computer programing. (CH)

HIGHER EDUCATION and Final Papers presented at the Association for Educational Data Systems Annual Convention.

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ASSOCIATION FOR EDUCATIONAL DATA SYSTEMS

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Proceedings

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DESIGNING AN EVALUATION OF THE IMPACT OF COMPUTERS ON EDUCATION

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ABSTRACT. The Minnesota Educational Computing Consortium (MECC), with support from the National Institute of Education (NIE), is designing a study of the impact of administrative and instructional computing on elementary, secondary, and vocational education in Minnesota. This paper describes the goals and scope of the study, discusses methodological considerations and their relation to goals, and presents a very preliminary list of questions to be answered by the study. It is hoped that the study will provide information useful to educational computing on a national level, and suggestions, criticisms, and reactions are invited.

Background

On July 1, 1973, The Minnesota Educational Computing Consortium (MECC) was created by a Joint Powers Agreement among the University of Minnesota, Minnesota Community Colleges, the State College System of Minnesota, the Minnesota State Department of Education, and the Minnesota State Department of Administration. The purpose of MECC is to provide consortium members with requested educational (instructional and administrative) computing services. The word "requested" in the preceding sentence must be emphasized; MECC users decide if they want to use the computer in education, and if so, how it is to be used. MECC itself is totally non-directive. MECC staff members help users do what the users decide should be done. Each user sets his own computer-related objectives and determines the means by which his objectives will be met.

MECC provides instructional computing service through a statewide communications network linking over 1,300 terminals to a single UNIVAC 1110 computer located in Lauderdale, Minnesota, a suburb of St. Paul. Over 70% of Minnesota public school districts (K-12) are served by this network, 85% of which are located outside the Minneapolis-St. Paul metropolitan area. Over 90% of Minnesota's public school students are in these districts.

MECC's administrative service is still being developed. Administrative computing in Minnesota is presently handled by Total Information for Educational Systems (TIES) for 45 districts (serving over 250,000 students), and by several individual districts, e.g., Minneapolis, St. Paul, and Rochester, Minnesota. The TIES system is the model for MECC's administrative system.

The Computer Impact Study

During the 1975 Minnesota legislative hearings on the appropriation for MECC, it became evident that there was a need for an evaluation of the educational impact of computing. Asked to provide evidence for the cost-effectiveness of educational computing, MECC staff could provide nothing beyond a summary of experiments comparing CAI and "traditional" instruction. This was not because the MECC staff was uninformed--there were simply no better data available, a surprising if not appalling fact when one considers the millions of dollars that have been spent on instructional computing in this country.

At about the same time, officials of the National Institute of Education (NIE) became interested in MECC as a prototype for educational computing systems in other states and asked MECC to submit a proposal for an impact study to NIE's Office of Finance and Productivity. Because of MECC's interest in evaluating impact, this was done, and after a series of meetings and written communications between MECC and NIE, a contract was awarded to MECC in early 1976 for the design of a study which would evaluate the impact of administrative and instructional computing on elementary, secondary, and vocational education in Minnesota. The design is to be completed by September, 1976, and if it is approved by NIE, MECC will receive a contract to perform the study.

Goals of the Computer Impact Study

The primary goal of the Computer Impact Study is to provide information useful in the resource-allocation decision-making process. An idealized version of this process is outlined in Figure 1. The decision-maker faces a set of alternative programs defined by different mixes of available resources. In input/output terminology, the resource mix is the input. The output is the performance of the program. Each alternative resource mix has associated with it a cost which must be weighed against the benefits of program performance in determining the decision-maker's preference for the program relative to alternatives.

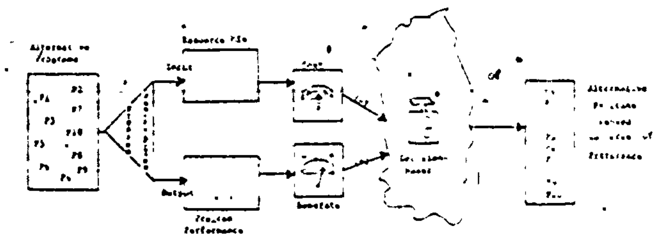

FIGURE 1. The resource-allocation decision-making process Adapted from Levine (1971)

The utility of the cost and benefits information provided by the study will be determined by the setting in which the resource allocation decision-maker is working. The secondary goal of the study is to provide information useful to decision-makers in three different settings: summative evaluation, formative evaluation, and program design. The function of cost and benefits information in each setting is summarized below, along with an example of a decision-maker in each setting.

Setting	Function	Example
Summative Evaluation	To support decision-making in program adoption/continuation.	Funding Agency, e.g., the State Legislature
Formative Evaluation	To support decision-making in program improvement.	Program Staff
Program Design	To support decision-making in other contexts vis a vis program design and improvement by providing generalizable information on program cost and effectiveness.	Outside observers interested in designing a similar program, e.g., The Department of Education of another state.

Defining "Computer Impact"

Previous studies have defined "computer impact" quite narrowly, focusing on comparisons of student achievement and attitudes in specific computer-assisted instruction (CAI) programs, usually of the drill and practice variety, with "traditional" courses. As a source of information on the impact of educational computing, this kind of study leaves much to be desired.

The most serious difficulty with such studies is their restricted scope. These studies, by focusing on achievement and attitudes produced by a single CAI program, miss the important general educational effects of the computers. They tell us nothing about the impact of the computer on curriculum content or methods, school organization and management, or faculty activities. To quote Hunter, et. al. (1975), who report the results of the most comprehensive study of educational computing yet conducted, "there have been no large-scale investigations of the more important general educational effects of adopting computer-based systems and curricula....In the present study, we did not go 'behind the classroom door' in any systematic way to determine what real effects, if any, the computer-based innovation was having on curriculum content or methods, activities and achievement of students or school organization, management, and goals. We also do not know of anyone who has done this."[1]

Our definition of computer impact, which is shown in Figure 2, attempts to capture the important general educational effects referred to by Hunter, et al., (1975). The computer system is input to the environment (the educational system). The computer's impact is determined by the characteristics of both the computer system and the environment in which it is placed.

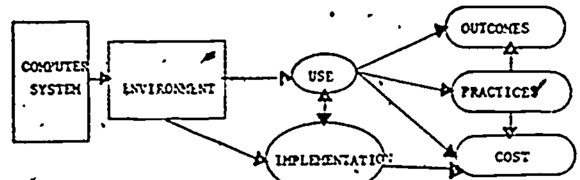

FIGURE 2. A definition of computer impact.

Impact is defined as five different but independent outputs: use, implementation problems and solutions, outcomes, practices, and cost. Brief descriptions of the outputs are given below:

Output	Description
Use	How the computer system is used, e.g., what programs are used and who uses them.
Outcomes	Student achievement and attitudes.
Practices	Roles and activities of teachers and administration, school management, and curriculum content and methods.
Cost	Cost of acquisition and operation.
Implementation	Problems in implementation and possible solutions.

Methodological Considerations

Most impact studies have used an experimental approach to research design. Carefully designed experiments or quasi-experiments (Campbell and Stanley, 1963) are used which compare the performance of an experimental group with that of a control group. The treatment that differentiates the two groups, e.g., presence or absence of CAI, is called the independent variable. The performance on which the two groups are compared, e.g., test scores, is called the dependent variable. Changing the value of the independent variable is believed to cause changes in the value of the dependent variable.

The experimental approach requires that decisions regarding independent variables must be made by the experimenter. The experimenter, for example, must be able to decide which CAI program should be presented, how long it should be presented, and to whom it should be presented. As suggested earlier, this requirement cannot be met in our situation. None of the variables in our impact model (Figure 2) can be controlled by an experimenter. Where the power to control exists, it belongs to each user of the computer system. This is, of course, as it should be, given our interest in determining the educational effects of computers in real-world environments.

When the experimenter has no control over variables, the most appropriate methodology is the "non-experimental" or correlational approach. In a correlational study, there are no independent variables. The values of uncontrolled variables are measured and statistics describing the degree of relation between variables are derived. A relation between variables does not imply that changes in the value of one variable cause changes in the value of another, but it can be used to predict the value of a variable from knowledge of the value of a related variable. That is, a relation allows prediction of performance, but does not allow the inference that the prediction is based on a cause-effect relationship.

The correlational approach will allow us to determine relations among variables. These relations can be used to predict the values of variables from knowledge of the values of other variables. Will this methodology allow us to achieve the goals of the Computer Impact Study? We think that it will. We believe that the relationships produced from uncontrolled, real-world data by the correlational approach are more appropriate for resource-allocation decision-making than the experimental vs. control-group information produced by the experimental approach. Project designers will obviously be most interested in predictive relationships. If the sample is sufficiently representative that the relationships can be generalized to other contexts, project designers should be able to draw useful inferences about the relation of computer-resource allocation and educational impact. Decision-makers involved in formative evaluation will be able to use information on the relationships of variables to identify program elements which should be strengthened, added, or deleted. Those interested in the "yes-no" decision of summative evaluation may find many of the predictive relationships produced by the correlational approach irrelevant and prefer the simpler indication of the presence or absence of difference between experimental and control groups produced by the experimental approach. This sort of information can be distilled from relational data, however, using summary statistics on the magnitude of relations.

Questions

The first step in designing the Computer Impact Study has been to ask legislators, educators, and private citizens in Minnesota and educators from a sampling of other states to identify questions that they would like to have answered by the study. A summary of the questions we have received, organized by the impact elements shown in Figure 2, is given on the following pages. The next step is to generate additional questions and to define and operationalize variables which will allow us to answer as many questions as possible. We plan to develop measurement instruments during March and April, 1976 and to conduct a pilot study during May, 1976. The pilot data will be analyzed and the design for the study will be completed during the summer.

Your questions, criticisms, and suggestions are welcomed. We believe that this study can produce answers to many important questions, but only if concerned citizens and educational computing professionals help us identify these questions during the design of the study.

Computer System

1. What are the advantages and disadvantages of a large, centralized computer system serving all users? of several small, decentralized computer systems, each serving a few users?

2. Who is best served by a large, centralized computer system?

3. Who is best served by a small, decentralized computer system?

4. What administrative applications are available?

5. What instructional applications are available?

6. What unavailable administrative applications are needed? By whom?

7. What unavailable instructional applications are needed? By whom?

Environment

1. What are district/school/class objectives?

2. What are the characteristics of students--number, socioeconomic status, standardized achievement scores, age, etc.?

3. What are the characteristics of the staff--number of certified teachers, experience/education of teachers, number of para-professionals, number of special teachers, number of administrative personnel, etc.?

4. What are the characteristics of the community--population, geographic location, median income, etc.?

5. What are the operational characteristics of the school--instructional time per student, maintenance cost per student, etc.?

6. What are the physical characteristics of the school--space, furnishings, etc.?

Use

1. Who are the users?

2. Who are the nonusers?

3. What administrative applications are used? How and by whom?

4. What instructional applications are used? How and by whom?

Implementation

1. What are the optimum times of the year to implement the computer?

2. How much staff training should occur prior to implementation? What kind of training is necessary?

3. What organization (centralized staff, district, school) should be responsible for necessary staff training?

4. How many terminals should be placed in the school? Where should they be placed?

5. How should terminal use be scheduled?

6. How should communications be handled?

Outcomes

1. Does the computer increase learning?

2. How effective is the computer for different types of schools and different types of learners?

3. What is student and teacher reaction to the computer?

4. What is community and parent reaction to the computer?

5. Does the school function better (efficiency of school administration) with computer support?

Practices

1. What effect does the implementation of computer services for administrative purposes have on the clerical and administrative staff?

2. Do the faculty, administrators, and staff have more time to spend with students as a result of the implementation of computer services?

3. Has the computer had an effect on the curriculum?

4. Has the computer had an effect on school policy and organization?

Cost

1. What is the acquisition cost--e.g., for training, equipment, facilities, and materials?

2. What is the operational cost--e.g., for training, curriculum development, added salaries, materials, and supplies?

3. What are the critical cost comparisons for computer vs. noncomputer services?

General

1. What are the security precautions to protect against unauthorized use of computer files?

2. What are the curriculum areas where the computer might best aid learning?

3. Is the computer most effective in administrative services or as a tool to aid learning?

4. Can the computer add anything new to instruction? Can new instructional objectives be met using the computer? If so, how?

Footnotes

[1] Hunter, B., Kastner, C. S., Rubin, M. L., and Seidel, R. J. Learning Alternatives in U.S. Education: Where Student and Computer Meet. Englewood Cliffs, N. J.: Educational Technology Press, 1975, pp. 208-209.

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INSTRUCTIONAL AND ADMINISTRATIVE COMPUTING AT A MINORITY INSTITUTION IN A BICULTURAL-BILINGUAL SETTING

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ABSTRACT: In July, 1975 Navajo Community College installed a time-sharing computer system at their Tsaile, Arizona campus to service all the computing needs of this relatively new junior college. The rapid progress made in developing both instructional and administrative applications during the past ten month period will be described and reviewed.

An analysis of the successes and failures of this project to date will be given along with future plans for growth and enhancement. The unique requirements and problems of this bicultural-bilingual campus in a remote location and the methods being utilized to solve them will also be discussed.

I. INTRODUCTION

Navajo Community College, located at Tsaile, Navajo Nation Arizona, was founded in 1968 to provide special educational opportunities needed by Native American young people on the Navajo Reservation. This is the largest reservation in the United States, containing 14,500,000 acres over a three state area centered in northeastern Arizona. The college has attempted to be responsive to the needs of 140,000 Navajos (expected to more than double by the year 2000 at the present birth rate) on a land area the size of the state of West Virginia. Thus, its mandate and characteristics are different from those usually attributed to the community college.

The primary goal of the college has been to help students bridge the gap between the two primary languages, cultures, and societies in which they must live. It provides a stepping stone to upper level college experience for some and skills for immediate employment in technical/vocational areas for others.

The students who attend the college are 80% Navajos, and for many of these students English is a second language. As a result a number of the courses - particularly in the Indian Studies program-have at least one section taught in Navajo. The remaining 20% of the students are about equally distributed between other Indian tribes and non-Indian students.

It should be noted that this was the first Indian operated and controlled college on an Indian reservation in the United States. As a result, the college has become the founding sponser for a ten member American Indian Higher Education Consortium (A.I.H.E.C.), headquartered at Denver, Colorado. The ten colleges are located throughout the Western United States.

The college has one major branch campus at Shiprock, New Mexico, and supports a number of programs at sites other than the main campus. Plans call for continuation of this outward growth to other communities on the reservation. In addition, the college manages a number of grants for outside agencies. As a result any administrative projects to be implemented have to provide for far greater diversity and complexity that would be typical for colleges of this size.

II. COMPUTING EXPERIENCE AT THE INSTITUTION

For several years the college had been utilizing services provided by external sources for their administrative computing needs. Northern Arizona University provided student record keeping for some time, but their distance to the college (about 250 miles) caused this service to be very difficult to utilize and became a serious handicap to the Records Office. On the other hand, those Business Office functions which were operational-primarily payroll and expense reporting-were being processed by the Navajo Tribal Data Processing Department in Window Rock, Arizona. Although much closer to the college, there were significant difficulties with this arrangement as well, including lack of direct control over the data entered, operational scheduling, and programming modifications. Finally, a remote batch terminal was installed at Tsaile connected to the Tribal Data Processing Department in Window Rock. After a somewhat lengthy transition period, the Director of Records had this remote batch system working smoothly by the summer of 1974. Unfortunately, shortly thereafter, the tribe announced a hardware vendor change which was relatively incompatible with the college's terminal, and another period of frustration had begun. During this time several consultants visited the campus. Several proposals were submitted to satisfy the Business Office and/or Data Processing needs, but little action was taken.

III. CURRENT SYSTEM SELECTION

Finally, in March, 1975, this author proposed that the $55,000 annual expenditure for d.p. services would be better utilized by purchasing an in-house time-sharing system. He also volunteered to spend a year installing the system and training college personnel to run the center thereafter. Documentation was provided to show that over a three year period the college would break even or save money with this arrangement. (This cost analysis did not even include the value of the additional services which could be provided, the advantages of local control, and most of all the instructional opportunities which had never been available previously.) In addition, a list of computer systems requirements broken down into the categories of required, highly desirable, and desirable items in both hardware and software were prepared for potential vendors. (This report is available upon request.) Because of the remote location for this new computer installation, with the nearest hardware vendor being located in Albuquerque, (230 miles away), while other prospective vendors were as remote as Phoenix (350 miles) and Denver (500 miles); a non-standard hierarchy of selection criteria were chosen. These are listed below in approximate decreasing order of importance.

IV. SELECTION CRITERIA

- system capibilities
- vendor accessibility
- hardware reliability
- software capabilities
- hardware capabilities
- vendor flexibility
- local backup within the system
- vendor's interest in education
- cost/effectiveness
- data base capabilities
- system integrity & security
- language capabilities
- ability to support a wide variety of terminals

The system finally selected was a DEC 11/35 system (known as a DEC 11/40) which was purchased from a software house, EDUCOMP, in Hartford, Connecticut. It should be pointed out that a Hewlett-Packard 2000 Access System was in the running until the final decision was made.

The configuration selected was designed to minimize loss of service because of any piece of equipment being down. Hence, no card reader was selected, printing terminals were required to have similiar capabilities to the line printer (132 print positions, line control capabilities, etc.), memory segments had to be capable of being bypassed and no single auxillary storage devices would be obtained.

The system currently has 64K words (16 bit), a 300 line/minute printer, 8.4 megawords of disk storage (one half removable) and eight terminals (7 of them printing). These are distributed as follows: Two in Student Records, one in the Business Office, one at the Shiprock Branch, two in the library, plus two portable terminals. The latter four are primarily for instructional use, hence the current distribution of terminals is roughly equal between administrative and instructional applications.

Software purchased included a data base management system (a key acquisition to be discussed later), a student record system, attendance system, payroll package, and a Business Office system including accounts payable, receivable, general ledger, and budget reporting system. The software purchased represented approximately 1/6 of the total purchase price of the system.

IV. PROGRESS MADE TO DATE

After Board of Regents approval of this purchase in late May, 1975, the following list of milestones gives some indication of the progress made to date:

MILE STONES IN COMPUTING AT N.C.C. (1975-1976)

JULY	01	HARDWARE ARRIVES
JULY	17	MOST HARDWARE OPERATIONAL
AUG.	03	SECOND SUMMER REGISTRATION DONE ON-LINE
SEPT.	02	ALL HARDWARE OPERATIONAL
SEPT.	04	INSTRUCTIONAL AND LIBRARY APPLICATIONS BEGIN
OCT.	16	ATTENDANCE PACKAGE OPERATIONAL
NOV.	27	FIRST BUDGET REPORT RUN
JAN.	30	FIRST PAYROLL RUN

There are a number of reasons for the rapid progress made to date. Among these are the following:

1. Good local support and personnel. Although no computer main frame had been on campus before, those persons charged with data preparation and management had good job skills, and have been dedicated and thorough in the performance of their duties.

2. Good software support. New Mexico Military Institute (N.M.M.I.) from whom the student record system was obtained, has done an outstanding job of supporting, enhancing, and explaining whatever has been asked of them. They are to be commended for this effort, and it has been in marked contrast to some other software purchased.

3. The hardware has been very reliable for the most part, and has performed up to specifications.

4. The existence of an excellent data base management package. Although usually discussed in terms of large systems, good software for handling data bases is now available on many minicomputer systems and is extremely important to the small college taking this step. The GPRS system from EDUCOMP, which has been enhanced by N.M.M.I. is an excellent one. Examples of other good packages in existance include the WISE package developed at Wheaton College by Dr. Jacque La France (one version of which is marketed by DEC), and the H-P IMAGE packages for H-P 2000 and 3000 systems.

5. A good strategy or plan for implementation of the software, capable of being revised and modified as needed with good user support and cooperation.

6. Creative users with good ideas of what they need and want.

7. A willingness to work one's tail off until the systems are performing as required.

Fortunately, all these ingredients have been available at N.C.C. to bring the project to its present degree of completion.

V. ADMINISTRATIVE SYSTEMS DEVELOPMENT

To date almost all known student information requirements are fully developed. With some clever manipulation by Mr. Scott Fisher, Director of Research and Admissions, almost any request for information by H.E.W., the AI.H.E.C. Consortium, the Bureau of Indian Affairs, North Central Accrediting Association, or the college administration can be obtained with relative ease.

Payroll is running smoothly and providing a great deal of information which was not available previously. Although the other Business Office functions are not yet fully operational, by the time of this presentation all required software will not only be implemented, but shall be well integrated.

The data base package mentioned earlier has enabled the college to adjust quickly and easily to new requirements for information retrieval. Such diverse applications as reading test scores, a personnel file, a consortium library, and the college periodical current and archival files have all been implemented in a few hours to a few weeks depending on the availability and condition of the input data. Most important of all, the processing from data entry to retrieval has been done in most cases by the user-the person who knows his data and requirements best-with only minimal orientation and training.

VI. INSTRUCTIONAL USE

Although little original instructional software has been developed at the college to date, the existance of many useful packages in a variety of disciplines has caused approximately one third of the students on the campus to use the computer in some way during this first academic year. Some of the major uses to date have been:

1. Game-playing. Many good instructional games exist today and a number of these have been made available on this system. Benefits include developing student familiarity with the terminals, motivating better student reading skills, overcoming fear of modern technology, and good thought-provoking recreation.

2. "Canned" Simulations. The Huntington II packages contains a number of good simulations which have been utilized in the Nursing Program and the Biological Sciences. They seem to be highly motivating for the classes which have used them. One original program which has been developed here, is GENE 2, an extention of the well known GENE 1 program to two traits for use in genetic simulation experiments by students.

3. User written programs. The chemistry professor has written most of his own courseware, customized to his classroom requirements. This has been possible because of his motivation, background, and the ease of using the BASIC-PLUS language. A few students have written their own programs to help with homework assignments after using TUTOR, a self-instructional package on the fundamentals of BASIC.

4. English vocabulary. Several word games customized to the instructor's requirements have been successfully

used to enhance individual and group learning of English vocabulary.

5. Instruction in data processing and computer programming. These courses were not taught before the computer was on campus for a variety of reasons. Student interest has been high, particularly at the introductory level. The curriculum is still in a developmental stage, since it has been found that most of these students have considerable difficulty going from a problem statement to a computer program for solving it. Because of this, in the first course taught, Introduction to Data Processing, students are taught the fundamentals of coding in the BASIC language and how to code from detailed flow-charts to BASIC statements. Then in the second course (a programming class) they are taught to go from process (or overview) flow charts to detailed flow charts, and finally the structured design concept of problem statement to process charts. There is still much refinement to be done with this pedagogy, but it has broken down the learning into manageable skills for these students.

This has obviously just scratched the surface of the instructional potential. A number of projects being planned, researched, or hoped for include:

1. Ways to enrich the learning of fundamental study skills.

2. Ways to improve the learning of written Navajo and English.

3. Business, econometric, and small business simulations.

4. Political modeling in historic and current Indian-Anglo relations.

5. Selecting an appropriate career guidance package.

6. Choosing good targets for existing and customized CAI packages including such areas as welding, physical education, and basic electronics.

Again, there are many existing projects and instructional experiments that can and will be done to enrich the education of these students.

VII. FUTURE PLANS

As has just been shown in the instructional area, and despite the long strides which have been taken during the first year, there is even more to be done:

---Getting the Business Office on a current and timely reporting basis should permit better planning on the part of college administrators. The base is being laid for longer range projection and forecasting.

---The existance of COSAP II, a minicomputer version of a statistics package modeled after SPSS by Lawrence University, will be a beneficial tool for both students and teachers. However, a proposed refinement to enable this package to access all data base packages including student records should provide unprecedented and almost unlimited research potential for qualified users both on and off the campus.

---A Native American has been hired to direct this operation by fall, as the computer center is quickly moving to a fully self-supporting staff. This transition will be completed in at most 14 months after initiation.

---The existence of four new minicomputers on the reservation in the last year (there were none previously), opens the door to many new computer career opportunities for students on the reservation.

---The 40,000 public and BIA students on the reservation without any computer exposure whatever are an untapped resource and responsibility.

The main goals continue to be enrichment of the students' educational experience, and enabling more precise decision making on the part of administrators. It is hoped that the continued expansion of this system can benefit not only Navajo Community College, but all levels of education on the entire Navajo Nation--and other Native American Schools, as well.

EXPERIENCES IN INITIATING THE USE OF COMPUTERS IN INSTRUCTION

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ABSTRACT: This paper presents an overview of the evolution of instructional computing at City College of San Francisco. Included is a description of the procedure followed in acquiring a new computer, from the initial "grass roots" movement by instructional users through the role of faculty in the selection and management of the system. Some special features and facilities are described: dataBASIC (an easy to use data base management language based on BASIC) and the Computer Assisted Learning Center (CALC). Examples of the use of computers in learning situations are shown through the description of present applications by one department (Chemistry).

COURSES AND FACILITIES 1971

City College of San Francisco is the only two year college in the city. It serves a student population with a particularly broad variation in racial, ethnic and educational background, variety of work experiences and range of career goals. In 1971 the computing facilities consisted of an IBM 360/25 of 48K bytes for batch work using a FORTRAN compiler--clearly inadequate for a school of this size. Registration was being effected manually; the computer had been eliminated from this area owing to the results of a previous attempt which had proved less than completely satisfactory.

The following is a summary of some of the things we have done both in the Department of Chemistry and as a group in the college to arrive at the present situation.

THE COMPUTER SELECTION PROCESS

In the spring of 1972 the proliferation of demands for computer services and our evidently successful use of the time-sharing computer led to the formation of the Computer Users' Committee, comprised of students, faculty and administrators. The committee's aims were that present facilities be used most efficiently, that there be more recognition of instructional needs and that more and better services should be provided for the entire college community.

In the fall of 1972 the committee, considering usage projected for 1973 by academic departments, discussed possible approaches to increasing computer facilities for 1973-74 and subsequent years. Discussion during several meetings of the Computer Users' Committee identified essentially four alternatives:

a) to recommend the acquisition of a certain computer that was selected by administrative data processing personnel to satisfy the college's needs for both time-sharing and batch computing for 1973-74 and subsequent years;

b) to undertake a study of several competitive computer systems with the ultimate goal of recommending one for acquisition;

c) to make interim improvements for 1973-74 (this might have included the acquisition of a mini-computer or the purchase of time-sharing services from various possible sources);

d) to make no changes for the school year 1973-74.

The Computer Users' Committee decided to pursue alternative b) and appointed a Computer Selection Committee to undertake the study. The members of the Computer Selection Committee were four teaching faculty from Chemistry, Physics, Engineering, and Computer Science, the Registrar, a Dean of Instruction, two persons from Computer Services, a librarian, and a student.

There was common agreement among all the members of the study group that evaluations of competitive systems should be on the basis of their adequacy to satisfy the school's present and future needs, i.e. the system was taken as a black box without any attempt to analyze the hardware features. However, before any meaningful study could be taken along these lines it would be necessary to educate members of the college community about future possible directions and activities. (In the administration particularly, there was a tendency to avoid any consideration of additional use of computers because of a bad experience with computer aided registration a few years prior to the study.) Thus at the outset eight vendors were invited to to give descriptions of their computer systems and their capabilities to the study group and various key administrators. Following these presentations, the Computer Selection Committee settled on an evaluation procedure as follows:

1. Formal presentations of systems by sales, management and technical representatives.
2. Determination of selection criteria.
3. Final information gathering on all proposed configurations preparatory to selecting some of the systems for detailed analysis.
4. Detailed analysis of systems including on-site evaluation of identical systems already operating in a similar environment (at least two installations for each vendor).
5. Communication with present users as to reliability, ease of use, service, etc.
6. Recommendation of the Selection Committee to the Users' Committee for decision by the Users' Committee.

After the selection criteria were decided upon, the eight competing systems were evaluated on the basis of the following criteria

1. Adequacy of applications support
2. Adequacy of systems support
3. Potential and ease of expansion
4. Interactive time-sharing languages available
5. Adequacy of hardware maintenance
6. Ease of use of data management system
7. Space required
8. Price
9. Obsolescence
10. Design Criteria
11. Proven reliability of hardware and operating system
12. Compatibility of Batch and Time-sharing
13. Ability to perform 1401 administrative jobs without disrupting the system
14. Provision for interim services--especially time-sharing

and of these eight systems, four were selected for further evaluation. Additional criteria were applied to these four systems.

1. Performance as reflected on site visits (2 sites per vendor)
2. Attractiveness of C.A.I. capabilities and course author languages
3. Usefulness of the Data Management system
4. Ease of use of system by novices
5. History of maintenance in local area
6. Ability to process our 1401 languages
7. Adequacy of interactive languages and diagnostics
8. Number and desirability of additional programming languages available
9. Variety and number of instructional application programs
10. Extent and readability of documentation

At this point the committee was advised that a branch of city government had a computer system that could be made available to the college at attractive financial terms. This alternative was rejected due to the inability of the system to provide adequate time-sharing facilities. The committee selected a system, and just prior to its presentation to the governing board for approval, it was discovered that the chosen vendor could not deliver the system chosen for the price promised by the salesman. Though the committee was exhausted and exasperated, the evaluation process was re-initiated, using a new set of criteria and a new procedure, with the additional requirement that benchmarks be performed.

CCSF TEST SPECIFICATIONS

A. There must be a minimum of 32 physical lines (not software simulated) for time-sharing use. Thirty of these lines will have a student time-sharing job mix entered on them according to CCSF's specification and in a manner which must be approved by CCSF.

B. There should be provision for entry of local batch and remote batch.

C. The configuration on which the test is performed must have all components the same as the proposed configuration or any components which are not the same must have lesser performance in all respects. A letter from a company representative must outline any differences with the proposed and tested components and performance specifications for each.

D. Each manufacturer will supply standard manuals which outline the accounting information given at the conclusion of each terminal session or job.

E. Each manufacturer must be willing to commit that the results of the test be the substance of a performance bond that must be incorporated into the final contract.

F. The test will consist of six sub-tests.

1. Student time-sharing jobs only. Carriage return response times, compile times, and execution times will be measured. Carriage return response times must not exceed 1 second 90% of the time, 5 seconds 95% of the time and 10 seconds 99% of the time.

2. Student batch jobs only. Total elapsed time and processor times will be measured. The processor times must be one-tenth the processor time of the IBM 360/25 for the same jobs.
3. Student batch plus student time-sharing from subtests 1 and 2 above. There must be no degradation of time-sharing and no more than 20% increase in student batch elapsed time.
4. Administrative jobs. Total elapsed times and processor times will be measured. Programs in native-mode language must have one-tenth or less the processor time as the same programs on the IBM 360/25.
5. Administrative jobs and student time-sharing jobs from subtests 4 and 1 above. There must be no degradation in administrative throughput and no degradation of time-sharing on a minimum of ten terminals.
6. Administrative, student batch and student time-sharing with entry of administrative jobs on a remote batch terminal. There should be no degradation in the results of subtest 5 and no more than 40% increase in student batch elapsed time.

SYSTEM ANALYSIS

I. Minimum criteria

Any manufacturer failing to meet the minimum standards will be automatically excluded from further consideration.

A. Time sharing and batch capability

1. All manufacturers must guarantee to to meet the test standards detailed on attachment A.

2. Minimum language capabilities include:

Batch
a. COBOL (FULL ANS)
b. FORTRAN (ANS)
c. AL
d. RPG or other REPORT WRITER

Time sharing
a. BASIC
b. APL
*c. FORTRAN
*d. AL
*e. COBOL

*Fully compatible with Batch and able to interact with batch created files

B. Manufacturers support

1. Systems support
a. The manufacturer will update the operating system, major language subsystems, and utilities with new releases free of charge, including free installation to full operational status.
b. The manufacturer will provide 15 hours a month minimum of regularly scheduled visits by a systems engineer for consultation and advice to operations staff on software problems and to users.

2. Hardware support
a. Hardware maintenance will be on a regularly scheduled basis to insure continuing operation.
b. Manufacturer will provide CCSF with the option of emergency service on a 24 hours per day basis.
c. The manufacturer must guarantee to meet GSA standards for system uptime.

3. Application support
a. All present administrative applications must be executable on the new system.

4. Operations and systems training for personnel
a. The manufacturer will provide complete and ongoing training for at least four CCSF personnel.

C. Ease of expansion

1. The system must be upgradable to 128 terminals without the replacement of the main frame and with no degradation of the response standards established in attachment A.

D. Ease of communication with T-S EXECUTIVE

Prompting on log-in;
Go into language system with single command;
Addition, replacement, or deletion by line number reference;
Simple run command to compile & execute current program+
Simple retrieve & save by reference to name of program.

E. Physical facilities required

1. The system must require no more than 900 square feet total.

F. Scheduling algorithm with onsite parameter input.

G. Minimum Hardware Configuration

1. 1000 LPM printer with OMR registration
2. 1000 CPM reader
3. 250 CPM punch
4. 3 Tape drives 9 track, at least one dual density 800/1600 bpi
5. 2 disk spindles--total capacity 50M bytes

II. Weighting criteria

Criteria	Minor	Major
A. Time sharing capability		
1. Test results		35%
2. Languages		15%
a. BASIC		
b. FORTRAN		
c. COBOL		
d. AL	10%	
e. RPG		
f. BAL		
g. A string processing language--e.g. SNOBOL and/or LISP	2%	
h. Mathematical array language--e.g. APL (TTY comp.)	2%	
i. Pl/1 or similar	1%	
B. Manufacturers support (including personnel)		15%
1. Systems support	5%	
2. Hardware maintenance	5%	
3. Application support (including a data management system)	3%	
4. Vendor educational support	2%	
C. Hardware factors		15%
1. RJE	1%	
2. Average cost/terminal including communications equipment Core, Disk, Drum, etc. All costs exclusive of actual terminals.		
a. Up to 64 terminals	3%	
b. From 64 to 128 terminals	3%	
3. Amount of disk storage	2%	
4. Cost and amount of add-on disk	1%	
5. Capacity for high speed synchronous ports such as required for graphic display	2%	
6. Maximum number of terminals weighted logarithmically	3%	
D. JCL simplicity		20%
1. Time sharing capability	10%	
2. Batch capability	5%	
3. Degree of similarity--batch and time sharing	5%	

As a result of this evaluation the committee selected a Honeywell 6023, a configuration put together by Honeywell for the first time for this proposal. The system was installed in June-July 1975 and has met our needs and expectations to this point.

Part of our evaluation procedure was based on the experience gained by the selection team at Milwaukee Area Technical College (1). More recently, two other useful references have appeared (2, 3).

COURSES AND FACILITIES 1976

The enrollment in the College has increased to 26,000 day and evening students, with concomitant diversification in nationality, race, and preparative background. This widening spectrum of several dimensions is causing problems which we have not as yet solved. The recently installed Honeywell 6023 has core storage for 128K words and 30 terminals, and plans exist for increasing these to 192K words and 120 terminals. There is compilation software for the following high level languages in both interactive and batch mode: BASIC, FORTRAN, APL, PLANIT, COBOL, etc.

THE COMPUTER ASSISTED LEARNING CENTER

Initially, instructional computer usage at CCSF was dominated by the Computer Science Department, and of course, that department, with over 800 students, still constitutes a large segment of time-sharing users. However, many other disciplines now use the computer for instruction, simulation and testing. In addition to instruction in programming, students in chemistry, physics, mathematics and engineering run locally written programs to analyze data, make calculations, and simulate experiments.

The Dental Assisting Department has an interesting application which involves testing. Each year the students who are about to graduate take a test, at a terminal, which is composed of sample questions from the California State Licensing examination. The computer checks each answer as it is given, and responds with right or wrong answer messages. Since this program has been in use, the number of students passing the licensing exam on the first try has dramatically increased.

Sociology students use system library programs to do statistical analyses on their data, and run a program which explores sex role attitudes and stereotypes. Business students use the computer both for calculations and for simulations. The Architecture and Engineering departments are planning heavy use of graphics capabilities using a graphics terminal and tablet. Many students use on-line tutorials to learn FORTRAN and BASIC. These are only examples; new users and new applications surface constantly.

One unforeseen phenomenon is the great use of time-sharing facilities by "drop-in" or chance users; that is, students who are not taking any courses which require use of the system, but who wander past the terminal area, inquire as to what those "machines" are, and later become regular users, learning to run existing programs and to write their own.

The terminal area is called the Computer Assisted Learning Center (CALC), and is part of the Learning Resource Center. It began as a few teletypes, connected to the HP 2000 mentioned earlier, which were placed in a corridor of the library, along with typewriters and copy machines. The terminals became very popular, and it soon became evident that supervision and instruction were necessary. A nearby room was remodeled to house the terminals, which soon grew to ten, and a member of the library staff volunteered to manage the area. Demand for timesharing access grew, demand for broader language capabilities grew, and demand for file space grew, which resulted ultimately in the acquisition of the Honeywell system to meet those needs. Again the area was remodeled, and now houses ten CRTs in one room and ten teletypes in the other. Both rooms have blackboards so they may be used as classrooms. We expect to have a large wall-mounted video monitor installed soon, so that students may see exactly what the instructor is doing.

STUDENT ACCESS TO TIME-SHARING

CALC provides probably 90% of the student access to time-sharing, supplying nearly 50,000 hours of connect time annually. Student consultants, who are proficient in various languages and conversant with the system in both batch and time-sharing modes, are on duty almost every hour that CALC is open. They give orientations, assist faculty users, instruct novice users, and aid students who are working on assignments or independent projects. In addition, they do programming for faculty and administrative users on request, and provide all of the programming support for a wide variety of Learning Resource Center applications. Other CALC student aids prepare data, either keypunched or entered directly at a terminal, for LRC and faculty projects.

CALC maintains a library of system manuals, data processing equipment information, materials about educational applications, and orders self-instructional materials and books about computers. CALC loans portable terminals to faculty, arranges for temporary transfers of terminals to various locations for demonstrations, etc., and serves as a central information and service center for system users. The coordinator of CALC also provides tailored bibliographic searches of the numerous on-line data bases available from Lockheed's DIALOG and System Development Corporation's ORBIT systems.

The future promises two exciting and propitious developments. First, we are beginning to implement an on-line data base, using dataBASIC (4), of self-instructional and review materials available in various locations on campus. Each title will be retrievable by title, subject, descriptors, type (instruction, review, test, etc.), level (elementary, intermediate, advanced, etc.), call number, location, and medium (cassette, workbook, etc.). Included in each record will be publishing information and the length or number of parts. The data base is designed to aid instructors in directing students to appropriate resources, as well as enabling students to find materials by themselves. Built into the system is a file in which requests are stored, so that we can determine what materials to obtain to fill unmet needs. We foresee the development of similar data bases of school, career, and community services information (see Appendix).

We expect to integrate a great deal of computer-assisted and computer-managed instruction into the curriculum, using PLANIT (5) and components of a computer-assisted test construction system. The student body at CCSF is a particularly heterogenous group, yet in one way almost half of it is alike. About 50% of all students entering the college are required to take remedial-type mathematics and/or English courses. Many students repeat those courses. We believe that much of these instructional functions can be better handled using computer-based techniques, because of the enhanced ability to individualize learning. GED or high-school graduation equivalency instruction will also be implemented, as mentioned below in the discussion of the department of Chemistry. CAI and CMI will probably also become extensively used in nonremedial instruction, for example, to present short courses, (as recently authorized by the California State Legislature), and independent study sequences, in various disciplines. Such applications could be very useful at the College's satellite community centers as well, enabling students who cannot, because of their life situations, attend the normally scheduled and structured courses now offered. CALC staff will provide the instruction, technical assistance, and file-building support necessary to implement such activities.

EVOLUTION IN CHEMISTRY

At the time we joined the Department of Chemistry at this college in the Fall of 1971, only one other faculty member, like ourselves, had had computing experience in chemical research, but no one had had it in Education. Thus we were very unsure as to where or how to make a start. Courses offered in the department fell into three categories, with no use being made of computers.

A) High School parallel courses for remedial students:
 - Chem H, of the terminal variety
 - Chem 40, somewhat more rigorous, leading to University parallel work
 - Chem 8, problem solving

B) University parallel courses similar to those of the same number at the University of California at Berkeley:
 - Chem 1A, 1B, the standard freshman offerings
 - Chem 5, quantitative analysis
 - Chem 8, organic for pre-professional students
 - Chem 12A, 12B, organic for chemistry majors
 - Chem 10, for liberal arts majors
 - Chem 14, thermodynamics

C) A chemical technology curriculum:
 - Chem 61A, 61B, 61C

The department currently has examination item banks for several courses. These item banks are being used with computer assisted test construction programs to prepare examinations for these courses on a regular basis. We have made the initial implementation of a data base of self instructional materials for chemistry and we have accumulated a library of drill and practice programs, many of which are described below in connection with specific courses. In general however these programs are quite generally useful to some students in all of our chemistry courses.

We are currently modifying a variety of application programs in Chemistry as supplied by Digital Equipment Corporation. Among these are MOLE (6) for practice in gram/mole relationships, BOND (6) for exercises in chemical bonding, REAC (6) on calorimetry, KMNO (6) for redox titrations, PHOH (6) for simple acid/base relationships, NUCL (6) for balancing nuclear equations, ATWT (7) for atomic weights from isotope abundance, DECAY (7) for radioactive kinetics, EMPIR (7) for obtaining empirical formulae, EQUIL (7) for observing concentration constraints on equilibria, MASSD (7) for computing mass defects, GASLAW (8) for applications of the ideal gas law, and RAOULT (8) for colligative properties. All of these use a dialect of BASIC, and have themes sufficiently general to be useful in many of our courses and to students at various levels.

CURRENT USAGE IN INDIVIDUAL COURSES

Chem J: This course is geared especially for the needs of our less mathematically qualified students and uses a text written locally (9) which emphasizes the actual setting up of a problem for solution. Since there is a very large variation in the backgrounds of the students enrolled, this course is ideal for the use of CAI, and consequently we now use a variety of programs for individual learning, including Logarithms, Scientific Notation, and Metric System (all of which are based on CBIS (10) programs), Gas Laws, and the Mole Concept.
Since we view this course also as one where the students should learn some mechanical skills, they are encouraged to solve a given problem in a large variety of ways, which include desk calculator manipulation and simple use of FORTRAN. Problems which we have looked at in this way range from simple Temperature Conversions to KTOBETA, the computation of overall formation constants from input stepwise constants K{j} for any complex system of chemical equilibria, followed by testing for the tendency of a species to disproportionate.

Chem 40: We currently use only ELFIG, a local modification of Davis and Cross program (11) for tabulating the electron configurations and energy levels for any string of elements, and EQBAL (12) of local origin for balancing chemical equations of N terms by Gaussian triangularization of a matrix of rank N. This program differs from Brown's (13) in viewing the problem as one of N homogeneous linear equations, in employing the elimination method, and in using only one matrix of rank N, instead of the (N-1) cofactors of many authors (14). This method also has an advantage in that it produces the coefficients as relative primes.

Chem 1A: A routine for tabulating the Boltzmann Distribution for a gas has been used for some time and more recently we have added programs for linear least-squares analysis of data for experiments to determine the heat of vaporization of organic liquids according to the Clausius-Clapeyron equation and the heat of solution of inorganic solids. We are about to include several more. Among these are procedures for solving net ionic equations, for obtaining the precise pH of a polyprotic acid, for computing the Rydberg constant from the hydrogen spectrum (all these of local origin), for calculating van der Waals' volume (15) and for comparing the lattice energy of simple crystals as calculated both from the Madelung formula and from the Born Haber cycle (16).

Chem 1B: The following programs are used, some of them developed locally from scratch while, others are local modifications of programs obtained from other sources: ELFIG, as described above (11). MAGMON, based on Brown's program (17) for computing three models of the paramagnetic moment given the appropriate quantum numbers. ABTIT (18) a procedure for calculating and plotting the neutralization at any point in the titration as calculated from the cubic equation for the weak acid/strong base situation usng a Newton-Raphson technique to any desired accuracy. The first and second derivatives with respect to the concentration before reaction of added bases are then computed. After tabulation, all three functions are then plotted, although, for the sake of visual clarity, the second derivative H2 is replaced by SIGN (ALOG10 (ABS (H2)), H2) which also illustrates the remarkable drop at neutralization. CMISP, which calculates the molar solubility of a salt with known solubility product in the common ion situation (19). From the equation of interest (A + nx)}n{(mx)}m{ - K{sp} = 0, the lesser of the two approximate solutions log{e}x = log{e} (K{sp}/n}n{/ m}m{)/(n+m) and log{e}x = log{e} (K{sp}/ A}n{/m}m{)/m, each obtained by neglecting one of the terms in the compound factor (A + nx), is chosen as the zeroth trial for Newton-Raphson iteration. Convergence is usually obtained to the criterion ABS ((x{i+1}-x{i})/x{i}) < 10}-7{ within 8 cycles. PESFC, a local modification of Zavitsas' program (20) for plotting potential energy surfaces for atom transfer reactions utilizing the Morse equation. QUAL (21) which randomly selects an unknown consisting of two or more cations, accepts input describing laboratory operations "ADD reagent, HEAT, DISSOLVE", etc. and describes the outcome of such action (e.g. A WHITE PRECIPITATE IS FORMED). The student may identify the cations in the original unknown based on these reports of outcomes. FROST, a routine on a small HP 9100, for plotting Free Energy-Oxidation State (Frost) Diagrams (22), as developed by Mueller and Naumann (23) of this department.

Chem 8: For two semesters we have found a few larger programs useful in teaching some concepts we would otherwise not have attempted to teach. MOCLC, is an extended Huckel Molecular Orbital calculation, based on the one listed in Wiberg's book (24). The simpler concepts of quantum mechanics (eigenvectors, eigenvalues, orthonormality, electron density, pi-bond order, etc.) have been found to be quite teachable using this method. ISANE and ISALC are based on the program of Davis et al. (25) for calculating the number of isomers of the alkanes and alcohols (or alkyl groups) respectively. The latter program computes all isomers of each class (primary, seconday, and tertiary) while the former computes all isomers in nine classes up to 29 carbon atoms (we are limited to integer arithmetic because of round-off errors in the floating-point). By no means the least useful point here is that the mathematical principles of Gaussian congruences and the centric and bicentric trees of Cayley (26) are shown to be useful in a chemical situation.

Chem 14: This course has traditionally treated only Classical Thermodynamics, but this semester we plan to implement the introduction of Statistical Mechanics with several programs adapted from those developed in Gwinn's (27) laboratory for obtaining thermodynamic functions from the rotational and vibrational partition functions. This course has no computing prerequisite, but the students are select and at present seem mature enough not to mind being asked to swim after having been thrown into the deep end of the pool. So far they have been learning batch techniques with such procedures as numerical integration and least squares.

A NEW COURSE: "COMPUTERS IN CHEMISTRY" (28)

This course, Chem. 7, now in existence for five semesters, was instigated primarily to strenthen our semiprofessional two-year course of study in Chemical Technology, but several of our scientific majors have also taken the course for credit. The only prerequisite is one semester of College Chemistry; it thus stands as a sophomore course. The catalogue description is thus: "General purpose automatic digital computers. Concepts of algorithm, language, and flow charts. Programming and numerical methods. Use of FORTRAN to solve problems in Thermodynamics, Kinetics and Structure." The text by Murrill and Smith (29) has been found to be satisfactory for our current needs as the principal text, although we arenow using the BASIC language to solve some of our problems, so that some supplementary text materials are also necessary (30). Other texts have also been used (31).

The lectures are designed to teach the student to set up the problems so that he is then able to submit his own jobs in his own time to the computer. Individual students are encouraged to manipulate, troubleshoot and add flexibilities to programs already in existence in our Department of Chemistry Computing Library. The one semester course may currently be broken down into; 3 weeks of Algorithm and Numerical Methods; 3 weeks of solving Chemistry problems at the terminal using the BASIC language; 5 weeks of solving Chemistry problems on the 6023 using the FORTRAN language; 3 or 4 weeks of work on individual assignments.

Many of our students have become so interested in the computational techniques that they have been employed by us in subsequent semesters to make further contributions. In fact, some of the graduates of the Chemical Technology program still collaborate with us. Not the least worthwhile aspect of Chemistry 7 is its furnishing of so many of the programs both modified and written from scratch by its students to our Chemistry Department Computing Library and ultimately to our other courses. The emphasis is on Chemistry using computers, rather than on computers using Chemistry; on problem solving rather than coding.

FUTURE PLANS IN THE DEPARTMENT

One of the long term problems in the Department is the proper placement of Chemistry students in introductory courses. Some of our students enter with deficiencies in science or mathematics and need remedial courses before entering university-level courses. We are presently making preparations to use Pattern Recognition (Artificial Intelligence) techniques with test scores on a battery of standardized tests as a way of screening these students. In addition, once these students are appropriately placed, there will be a greater use of self instructional materials to aid them. We expect to set up a terminal accessible base of self instructional texts, filmstrips cassettes and computer programs to facilitate their use by needy students. Tapes therein should include instructions on the introduction to general laboratory techniques and on the use of specific laboratory instruments and equipment (e.g. balances, NMR, and X-radiative techniques, chromatographs, polarimeters). Time-sharing terminals in the laboratories will afford us opportunities to develop computer simulated experiments (e.g. in chemical kinetics, qualitative analysis, calorimetry), checking of student calculations, and analysis of experimental results.

Owing to recent remodeling of our building at a cost of $2M, we now house twelve chemistry laboratories, nearly all of them each equipped with two jacks for time-sharing terminals and with color TV monitors. Our audio-visual and broadcasting departments are both well equipped and promise to be cooperative. Lastly, we are planning to reorganize our stockroom facilities. Included in these plans is the installation of a computerized Stockroom Inventory System: something along the lines proposed by Deutsch et al. (32).

LOOKING BACK

Our new computer system has now been on site for about eight months, and students, faculty and administrators all seem very happy with it. Somebody's Law, which states that computer applications will expand to exceed available system resources at a rate approaching or surpassing ten times the number of years left on the lease or purchase contract, is operating nicely. We already plan major upgrades in core, disk and communications facilities. The single most significant contributing factor here has been the increase in the administrative load and expectations, and is directly related to one of the most important things we feel we would do differently if and when we go through the selection procedure again. That is the "education" of the administrative staff concerning what is feasible, desirable, and logical in educational data processing with today's systems. When the Selection Committee began developing criteria for evaluation, and tried to include long-range growth factors, they were resolutely and adamantly told that all that administrative personnel wanted from the new system was the ability to do what they were doing then. They were told not to anticipate growth in administrative services or file space needs, and not to expect additional fiscal support from them. Now that we have a successful installation, and computer-based registration is a roaring success, everyone wants to automate everything.

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APPENDIX

SERIES 6000 dataBASIC

Honeywell's dataBASIC system provides for data base management and inquiry by combining data base manipulation capabilities with a BASIC type language. It permits a file to be constructed, maintained, retrieved, and deleted on a content-addressable basis. Records of any size, containing from one to hundreds of fields, may be created completely without record descriptions. The records are, in fact, self-described and processed on the basis of field names and values which are supplied by the user at the time of record storage.

dataBASIC differs from most data management systems in that:

a) it can be run interactively, i.e. the programs can be created and run in the time-sharing mode

b) it can be learned and used by non-specialists; a few hours with the manual is sufficient to allow anyone acquainted with BASIC to write a program

c) for many applications only a relatively few (5-20) lines of code are necessary in a program to retrieve the desired information

d) a body of text associated with the searchable record may be stored and retrieved. This non-searchable text may be used to append additional information about the item in standard English.

The dataBASIC system has many applications; the few listed below are suggestive of many other potential uses:

Personnel files, where an inquiry might involve all single, male programmers having FORTRAN application experience, and whose last rate change preceded January 1, 1966.

A medical index of symptoms and diseases to aid in the diagnoses of illnesses.

A directory of community service agencies retrievable by service offered, clientele served, location, fees and name of agency. (This application has been previously developed and implemented on a trial basis at CCSF)

There are many other potential applications but to our knowledge neither dataBASIC nor any other data management system has been used to retrieve descriptions of self-instructional materials for either students or faculty.

Application of a Small Timesharing System to the Undergraduate Business Curriculum

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ABSTRACT

Using an inexpensive Hewlett-Packard 2000E timesharing system, students in the College of Business Administration at the University of San Francisco are being exposed to extensive hands-on computing through out their four year course of study. From a market simulation and statistical laboratory in the freshman year through courses in computerized information systems and operations research applications to more complex applications of simulation in the senior year, the use of the computer forms an integral part of each student's educational experience. This paper describes the use of the HP 2000E at USF.

INTRODUCTION

"Every student in the College of Business Administration should be able to use computing as 'naturally' as they would use a pencil or pen." This is the basic philosophy underlying the use of the Hewlett-Packard 2000E in the College of Business Administration at the University of San Francisco.

Since acquiring the HP 2000E in November, 1974, its use has grown as students have been systematically required to use the computer in their course work and as the students have developed applications for other courses. From their freshman year through the last course in their senior year, business students interact with the HP 2000E as a regular requirement.

This paper will present an overview of the variety of ways in which the HP 2000E is used in the undergraduate business curriculum and attempt to indicate the costs and impact of this usage.

For a significant number of students in six of the courses required for all business majors, interaction with the HP 2000E system is required. In the following section the nature of each of these courses as well as the role the computer plays will be described briefly.

REQUIRED COURSES

BA 7 - Quantitative Methods-First Course

BA 7 is an introductory statistics course for business majors. It is ordinarily taken in the first semester of the freshman year For transfer students into the College of Business as well as for graduate students without certain core courses, it is taken in the first semester of their program.

The purpose of the course is to introduce students to various statistical techniques starting with charts and graphs for data, continuing through descriptive and inferential uses of the normal curve (means, standard deviations, t-Tests, etc.), and ending with simple and multiple regression analysis.

In this course, the computer is used to do the clerical tasks - the arithmetic - while the students time is devoted to setting up the analyses and interpreting the results.

The most compelling example of this use is in the consideration of multiple regression. How many step-wise linear regression analyses could a student be expected to compute by hand during his first semester of statistics? Students in this course perform at least three and often many more as they explore relationships among variables in their final projects.

The final project for this course is an attempt to bring all their work in the course together. It involves collecting data with an instrument of the student's own design (usually a simple questionnaire) and exhaustively analyzing it.

The main program used in this course is STATIC. This program is used to standardize the data format for a variety of statistical programs already available on the HP 2000E Contributed Library including HISTOG, T-TEST, REGRES, and ANVAR. A program for simple linear regression was added and each of the above programs was modified to increase the amount of data each could accommodate and to enable each to read data from a common array filled from data statements by the STATIC program.

BA 4b - Introduction to Business

BA 4b is the second semester of the freshman year course introducing the broad concepts of business to the beginning students. The course has always been difficult to define and is taught quite differently each Spring.

In this course, a version of the Huntington II Project MARKET simulation is used. The MARKET program has been used in a variety of ways - from multiple team competition extending over the entire semester to brief two team contests. The use of this engaging simulation introduces both interactive computing and the dynamics of the competitive market place the simulation was designed to illustrate.

BA 158 - Information Systems

BA 158 had been taught in a variety of ways. When accountants teach it, the focus is on the "Language of Business", accounting information; when communications specialists teach it, the focus is on communicating information. Now the focus is very heavily on computer uses in business in the broadest possible sense.

There are three goals in the course:

1. Provide strong background knowledge on computer uses in business;

2. Present some key current issues in computerized information systems; and

3. Build hands on experience in computerizing business applications.

The HP 2000E is used in achieving each goal but its most important function is in the last goal which revolves around the semester long development of model specifications for building a computerized MIS for a business context as the final project in the course.

The programs used in this course are those the students write themselves. However, two model programs are available to illustrate the minimum program which will meet the specifications given to the students for their own programs. These are:

INVEN - This program is used to keep track of sales out of inventory, re-ordering for replacement and receiving into inventory for a ten item warehouse. It is a model for the first activity of the semester.

PROLL - This program is a model for a simple payroll application which is the second activity of the semester. Ten hourly employees, paid ten different rates are provided with weekly and year to date pay information.

These two programs give the students a starting point from which they build their own system to perform similar functions in their final projects.

BA 190 - Operations Management

BA 190 is a required course in applications of operations research methods to business contexts. Ordinarily this course is taken in the Junior year by all business majors.

A special section of this course has been designed for non-quantitative business majors which emphasises the application of operations management methods rather than their calculation. For this experimental course the computer is invaluable since, as in the statistics course, the emphasis is on design and interpretation rather with the calculation left to the computer.

The course focuses on the development of a final project by each student in which the student applies various methods covered during the course to a business context which he develops. Free creativity is encouraged and more is usually received.

The programs used in this course include two designed specifically for various methods covered in the course (EVENT - a random event simulator and INVEST - a collection of financial calculations not otherwise available in the 2000E Library) and several programs from the 2000 Series contributed library (i.e., GLP - Stanford GSB's Linear Programming program, CPATH & GCPATH - critical path applications; and M/M/S - an introduction to queueing theory)

These five programs (EVENT, INVEST, GLP, GCPATH, M/M/S) form focal points for the course. In addition to these, uses for a wide variety of programs in the contributed library are presented.

The option is always available for a student to develop his own application. This has been exercised to a limited degree by the more adventuresome students.

BA 192a - Organizational Theory

BA 192a is the first semester of a two semester sequence taken during the senior year in which all the work required of business majors is brought together in considering the operation and management of a business. The "theory" semester concentrates on applying various theoretical models of organizations to the study of businesses.

Under a recently awarded implementation grant from the Exxon Foundation, the computer will be used to simulate various models of organizations enabling the students to collect and evaluate data in a laboratory situation before finally taking their skills into the study of an intact organization.

The program which will be used in this course is LESS - Art Cromer's University of Louisville adaptation of the Michigan Experimental Simulation System.

BA 192b - Organizational Problems

The "problems" semester of the BA 192 sequence is the last course in the College of Business curriculum. It is intended to be a place where all the previously learned skills are applied. Three activities are used in this effort - text cases, a project studying a real business organization and a "Top Management Decision Game."

The game used is the DECSN game in the contributed library for the HP 2000C/F by Joseph Nordstrom at Bowling Green University. While the substance of the game has been preserved, substantial modifications have been made to make interactive versions and versions which will accommodate up to 25 teams on the HP 2000E.

ELECTIVE COURSES

BA 199 - Computer Simulation in Business

Computer simulations in business is a course offered to give an increasing number of interested students an opportunity to explore novel uses of the computer in business. In general the first part of the course is spent studying some existing simulations and the last part is used by the students to develop their own. In the most recent version of this course, the EXPER SIM program LESS (mentioned as a source for future work in BA 192a) was used as a method for developing business simulations.

BA 199.7 - Computer Programming in Basic

Some students, especially those who transfer into the College of Business, find the heavy schedule demand of structured labs in the Computer Science courses does not fit well into their programs. For these students a course in computer programming in BASIC, which utilizes some Computer Assisted Instructional Modules developed on the HP 2000E, is offered.

STUDENT INITIATED APPLICATIONS

Until now, most student initiated applications have involved data analysis. Some students who continue in operations management type courses have used some of the programs introduced in BA 190 in their further work.

In one novel application, students in a course on Personnel Management designed a job information system as a model for computerizing a personnel office.

Because of the computer's visibility and accessibility, students do seek possible applications outside their regular course work for such things as keeping track of business fraternity alumni, data analysis for student projects, and a host of things of which I am probably kept unaware on purpose.

IMPACT & COST OF THE HP 2000E

Prior to the effort over the last 2 years, COBA students took their required computer programming course and never touched computing directly again. Only a few who continued to take courses in the Computer Science Department had any further direct contact with the computer. Now, more and more students continue to have direct hands-on experience with using the computer as a business tool through out their undergraduate careers.

Not all of the faculty in the College of Business are taking advantage of the facility. Faculty use grows more slowing, since it can not be required but must be developed. Progress is being made as the pool of sophisticated and eager students grows and can be used assist faculty in using the computer.

Cost

Cost is always an extremely important topic. The cost of each one of the uses listed here is so small as to be incalculable. Even gross cost allocations are probably inflated but some rough figures are possible. The system, with the 8 terminals now in use (out of the 16 possible) costs about $20,000 a year to operate. This cost is only for the hardware since management and software development is accomplished by personnel (Teaching Assistants, other students, and instructors) who would have to function and be paid in their roles whether the computer was there or not.

If one allocates half this total to each semester then it cost $50 per student who will be required to use the computer (over 200 students will be required to use the computer extensively during the Spring semester). If you take a more realistic number of students (at least 400 will make some use) then the cost becomes $25 per student. Allocating a third of the cost to a single semester (4 months) makes the cost for 200 students $30 and for 400 students $15.

Since the computer is universally available through out the College of Business (and the University for that matter) another figure might be used. There are over 800 students in the College and the cost to provide this openly accessible facility to all the students is about $25 per year.

The twenty-five dollars per student per year is a very low cost !! Making sure that each student gets $25 worth from the machine is part of the task assumed in trying to integrate computer use into the entire curriculum.

CONCLUSION

Every computer sophisticate looks forward to the next larger system. Working inside a thimble is not convenient. On the other hand, the solidly successful experience with the HP 2000E confirms an initial suspicion that 90% (or more) of the kinds of activities undergraduates in the College need can be done on a small timeshared BASIC system with considerable cost-effectiveness accruing because the system is not larger than the immediate need.

The HP 2000E has real limitations and a larger system could spur development of other applications. However so much is being done on the 2000E that, perhaps, it really is sufficient for the purpose of providing computing power in line with the goal stated in the first paragraph of this discussion.

The usage of the HP 2000E by students has two important features which it is useful to point out in conclusion: the students do and learn a lot and they enjoy it!

COMPUTERS, CONFUSION, AND COMPLACENCY*

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ABSTRACT: The educational community is in the midst of a revolution without precedent. Unfortunately this revolution has not been recognized to have fundamental importance by the majority of the academic world. I refer of course to the computer revolution and its implications. The revolution has at its heart the ability to routinely process and work with immense quantities of information of all types. However, the terriby important question of what information to process and what output to be derived therefrom has remained largely unanswered.

The purpose of this paper is to comment on academic computing, examine the good and bad, and to see what could be, compared to what is. Hopefully, the reader will be encouraged to take a hard look at the present scenario of academic computing, compare to the wild growth of technical capability and, most important of all, rethink what is taking place in the classroom in light of this information.

COMPUTERS: Hardware. The most important fact about computers is that they are, and are not likely to go away. We are already in the third generation since the computer genesis about twenty years ago and are about to have the fourth generation explode on us. The second thing that should be noted is the very wide range of capability in computers - from the very large "megabuck" general purpose systems to the more modest but nevertheless powerful systems based on minicomputers. The capabilities of the large computers go without question. However, it is just being understood that the term "minicomputer" is probably a misnomer. Coupled with cheap mass storage devices, mini's are performing very ambitious tasks at an order of magnitude less cost than previously deemed necessary.

This raises a third and most important observation about computers. The computer product line is about the only commodity that is steadily decreasing in cost while all others are steadily rising. The performance to cost ratio of mini based systems in particular has increased by such a dramatic amount in the past five years that it is doubtful whether the cost of computers is a serious barrier to their use in the classroom. However it is still easy to use cost as a rationalization of a decision not to use computers.

Software. In the early days of computing, there was no such thing as a casual user. The barriers of machine language, assemblers, and the like had to be surmounted before course content could be treated. This had the predictable result that the classrooms of the nation were almost a complete computer vacuum. Software developments have changed this dramatically. Now, only a few hours of work are necessary to introduce the professor or student to the computer, and to enable viable use to begin. This is a mixed blessing however. The early computer practitioner spent the majority of his time in details of computer useage and the minority in curriculum related activities. Now, the situation has been completely reversed. Almost no time is needed to learn how to use the computer. Now the most frightening question of all is thrust squarely in the lap of the professor. How should the computer be used? How should the course be different? We are very far indeed from the answers to these questions.

Languages exist in profusion - FORTRAN, PL-1, APL, and BASIC to name a few. From a pedagogic point of view the interactive languages (APL and BASIC) are to be preferred for classroom use. The advantage being that results and errors generate immediate output that reinforce the educational experience with the student. The batch process approach far from being desireable may be counter productive unless the program turn around time can be kept less than an hour.

Practitioners tend to defend their favorite computer language with missionary zeal. It is probably a mistake to be drawn into this battle. Quite often, the fact that only a single language is available dictates that it must be used if the computer is to be used. It seems far more important to be concerned with what is being done with the language rather than which language is being used.

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Pocket Calculators. We certainly cannot afford to overlook the importance of the recent explosion of pocket calculators into the market. The realist must note, however, that the acceptance of pocket calculators in the classroom is taking place at a depressingly slow rate. One would expect that teachers of mathematics, physics, chemistry, engineering, and the other sciences would leap at the opportunity and inherrent advantages involved with use of pocket calculators. For a variety of reasons, most untenable, this has not taken place.

Most probably, students will force the issue of calculators in the classroom if it is not resolved by professional educators. As with computers, pocket calculators are not going to fade away. The educational profession must face up to this issue. We will return to this topic later in the paper.

CONFUSION: The Classroom Role Of The Computer. As indicated previously, it is far from clear just what should be done with computers in the classroom. The tendency to the present time has been to use the computer to do those things that were going to be done anyway, merely faster. This seems to be a very shallow approach to a most important question of fundamental importance. Given the power of the computer it would seem likely that the internal and external appearance of a course should be dramatically different. However, academic inertia is a law all its own. It is very difficult to make significant changes in course content and computers don't make the process any easier.

What is needed is a rethinking of the fundamental objectives of every course. The computer gives us the capability to short circuit the linear set of prerequisites dictating that course A precede course B which must come before course C and so on. If we are brutally honest with ourselves, there is an incredible investment of mathematics required to gain very modest returns in engineering and physics classrooms. Even with this investment the student is introduced to a somewhat artificial "laboratory world" where equations are always linear and solutions always seem to be at hand. More realistic problems either are not examined at all, or are simplified to the point where analytic methods can be used, but where the problem solved bears only passing resemblance to the original.

With the computer, the student faces no artificial limitations such as those described above. With almost zero mathematical investment students can become involved with the substance and heart of a course and obtain results which often cannot be obtained by analytical methods in any case. These applications do not need to involve monumental programming efforts. Far from it, very simple and elementary programs furnish powerful capability. Two examples will be considered to illustrate the point.

Problems Involving Forces And Motion. All engineering and science students spend a great deal of time working with motion problems involving Newton's Second Law. Most of the activity is a variation on a theme - given initial conditions and forces in the problem, obtain the closed form solutions for the velocity and position. The mathematical investment to handle this type of problem is two years of algebra, one year of trigonometry, and the best part of one year of calculus.

Let us now look at the same type of problem as structured for the computer. In difference form, Newton's Second Law becomes:

$$\frac{\Delta v}{\Delta t} = \frac{F}{m} ,$$

$$\frac{\Delta x}{\Delta t} = v .$$

With little effort it is easy to transform these equations to the form below.

$$v_{new} = v_{old} + \frac{F}{m} \Delta t .$$

$$x_{new} = x_{old} + v_{old} \Delta t$$

A very simple BASIC program to solve these equations is given in Figure 1. Note that most of the program is given over to remarks to clarify what is taking place. The most important line in the program is line 160. As given, the force is set equal to -10. However, if we want to examine any other case, all that must be done is to modify this single line. Thus, while the computer does not produce closed form solutions, it does produce numerical solutions to whole classes of problems with a single program. This program is very elementary and doesn't even have a stopping algorithm. When the user has seen enough he interrupts the program at the keyboard. Note also that the calculations could have been done equally well with a pocket calculator. All the mathematics that is required is about a half year of algebra at most.

```
100 REM INPUT INITIAL POSITION, INITIAL VELOCITY, MASS, AND DELTA T
110 INPUT X0,V0,M,D
120 LET T=0
130 REM PRINT OUT TIME, POSITION, AND VELOCITY
140 PRINT T,X0,V0
150 REM DEFINE THE FORCE IN THE PROBLEM
160 LET F=-10
170 REM COMPUTE NEW VALUES OF TIME, POSITION, AND VELOCITY
180 LET T=T+D
190 LET V1=V0+F*D/M
200 LET X1=X0+V0*D
210 REM RESET POSITION AND VELOCITY FOR NEXT CALCULATION
220 LET V0=V1
230 LET X0=X1
240 REM LOOP BACK FOR NEXT CALCULATION
250 GOTO 130
260 END
```

Figure 1 - Program For Newton's Second Law

The output of the program above is contained in Figure 2. The initial position was 0, the initial velocity +10, and mass 1, and the time increment 0.1. The first column in the printout is time, the second position, and the third is velocity. The program was interrupted at t = 2.0. Simple results like this can often lead to powerful conclusions. After using the program for some time, a student came to me with the observation that he could change the initial conditions, change the force to other constant values, but when the position data was graphed he always got parabolic results. Upon being asked why he thought they were parabolas, he replied "because they go up and down." The suggestion was made that possibly something a bit more precise could be learned if successive differences were to be taken of the column of position data. Of course, the student immediately discovered that the second differences were identical and the third differences were all zero thus confirming the fact that the curves were parabolas.

If the force is set equal to either the positive or negative value of the instantaneous velocity, the mathematically astute know that solution for position is an exponential function. Students, of course, do not know this. To illustrate, the program in Figure 1 was modified by changing line 160 to read

```
160 LET F = -V0
```

```
?0,10,1,.1
0          0        10
.1         1         9
.2         1.9       8
.3         2.7       7
.4         3.4       6
.5         4         5
.6         4.5       4
.7         4.9       3
.8         5.2       2
.9         5.4       1
1          5.5
1.1        5.5      -1
1.2        5.4      -2
1.3        5.2      -3
1.4        4.9      -4
1.5        4.5      -5
1.6        [illegible] -6
1.7        3[illegible] -7
1.8        2.7      -8
1.9        1.9      -9
2.         1.       -10

STOP
```

Figure 2 - Printout For Constant Force

The initial conditions remain the same as for the printout in Figure 2. After running this modified program, the same student referred to above was back with a very puzzled look on his face. He had obtained the printout with no difficulty but wanted to find out something about the nature of the position data. Using the same technique as before he took successive differences of the position data. His confusion centered on the observation that each of the columns of differences could be obtained from the previous one by dividing by -10. Furthermore, the process seemed to go on and on, not terminating as was the case with the parabolic position data. Only a few minutes discussion were needed to point up the fact that the student had discovered the nature of the derivative of the exponential function. The printout for the modified program is in Figure 2.

Of course, only two examples of motion problems have been discussed here. All that is required to look at any other problem is to make the appropriate changes in the line or lines in the program that define the force. We must point out that the numerical method

```
?0,10,1,.1
 0          0          10
 .1         1          9
 .2         1.9        8.1
 .3         2.71       7.29
 .4         3.439      6.561
 .5         4.0951     5.9049
 .6         4.68559    5.31441
 .7         5.21703    4.78297
 .8         5.69533    4.30467
 .9         6.1258     3.87421
 1          6.51322    3.48678
 1.1        6.8619     3.13811
 1.2        7.17571    2.8243
 1.3        7.45814    2.54187
 1.4        7.71232    2.28769
 1.5        7.94109    2.05891
 1.6        8.14698    1.85302
 1.7        8.33229    1.66772
 1.8        8.49906    1.50095
 1.9        8.64915    1.35085
 2.         8.78424    1.21577

STOP
```

Figure 3 - Printout For Force Proportional To Velocity

utilized (Euler's method) is highly susceptable to error buildup. However, simple changes that are easy to motivate can make the numerical approximation quite accurate.

Predator-Prey Model. The second example also illustrates the large returns that can be realized with a bit of mathematics and the computer. The example involves the classic Volterra predator-prey equations given below:

$$\frac{dx}{dt} = ax - bxy ,$$

$$\frac{dy}{dt} = -cy + dxy .$$

In these equations, a, b, c and d are all positive constants. The prey population is denoted by x, and y refers to the predators.

These equations are nonlinear and cannot be solved in terms of elementary functions. However, with a bit of mathematical slight of hand (requiring mathematical competency through differential equations) one can obtain a plot of x versus y.

The Volterra equations seem a bit artificial upon close examination. First, if the predators disappear the prey increase without limit following an exponential growth curve. This would require an environment with infinite resources which certainly does not seem reasonable. Secondly, if the prey population goes to zero, the predator population falls off exponentially. However, with the food supply gone, it would seem more reasonable that the predator population would drop to zero immediately.

The situation is made precisely for the computer. The Voltera equations are not too realistic, but at least a solution of sorts can be obtained by analytic methods. What we will do now is substitute a much more realistic model (due to Dr. William Dorn, University of Denver) without concern as to whether a closed form solution exists or not. The new predator prey equations are:

$$P_{new} = P_{old} + (A - BP_{old})P_{old} - CP_{old}F_{old}$$

$$F_{new} = DP_{old}F_{old}$$

In the new set of equations P refers to the prey population and F to the predator. The terms A, B, C, and D are all positive constants. Note that the difficulties pointed out in the Voltera equations are no longer present. If F ever goes to zero, the prey population increases following a logistic function to an equilibrium population of A/B. On the other hand, if the prey population ever goes to zero, the predator population also drops to zero immediately.

A BASIC program to solve the new predator-prey model is given in Figure 4. Again, note that very little if any mathematical sophistication is required to write such a simple program. In the equations, the constants A,B,C and D can be identified with physical parameters in the problem. This will not be done here as the point at hand is the ease with which the equations may be solved, not to derive absolute knowledge about the solution.

A typical output is shown in Figure 5. The first column is time, the predator population is in the second column, and the prey population in the third. It is quite difficult to see just what is taking place except that both the predator and prey populations seem to be following a cyclic oscillation with a time period of about 20. If, however, the predator population is plotted versus the prey population great insight is obtained. Such a graph is shown in Figure 6. Immediately relations become obvious that even well trained mathematicians likely could not see from the initial equations.

```
100  REM INPUT NUMBER OF PHEASANTS AND FOXES
110  INPUT P0,F0
120  REM INPUT CONSTANTS A,B,C,D
130  INPUT A,B,C,D
140  REM INITIALIZE TIME
150  LET T=0
160  REM PRINT TIME, FOXES, AND PHEASANTS
170  PRINT T,F0,P0
180  REM COMPUTE NEW FOX AND PHEASANT POPULATIONS
190  LET P1=P0+(A-B*P0)*P0-C*P0*F0
200  LET F1=D*P0*F0
210  LET T=T+1
220  REM RESET POPULATION VALUES FOR NEXT CALCULATIONS
230  LET F0=F1
240  LET P0=P1
250  REM LOOP FOR ANOTHER CALCULATION
260  GOTO 160
270  END
```

Figure 4 - Program For Predator-Prey Model

```
?10000,2000
?.2,.00001,.0001,.0001
 0          2000        10000
 1          2000.       9000
 2          1900.       8190
 3          1474.2      7583.64
 4          1132.63     7496.72
 5          849.104     7594.96
 6          644.082     7682.59
 7          507.672     8330.03
 8          422.895     8879.3
 9          375.581     9491.24
 10         356.397     10132.3
 11         361.111     10771.
 12         388.951     11376.1
 13         442.474     11914.7
 14         527.193     12356.8
 15         651.125     12644.4
 16         823.311     12751.2
 17         1049.82     12625.7
 18         1325.47     12231.3
 19         1621.21     11560.3
 20         1874.17     10661.8
 21         1993.19     9659.19
STOP
```

Figure 5 - Typical Output From Predator Prey Model

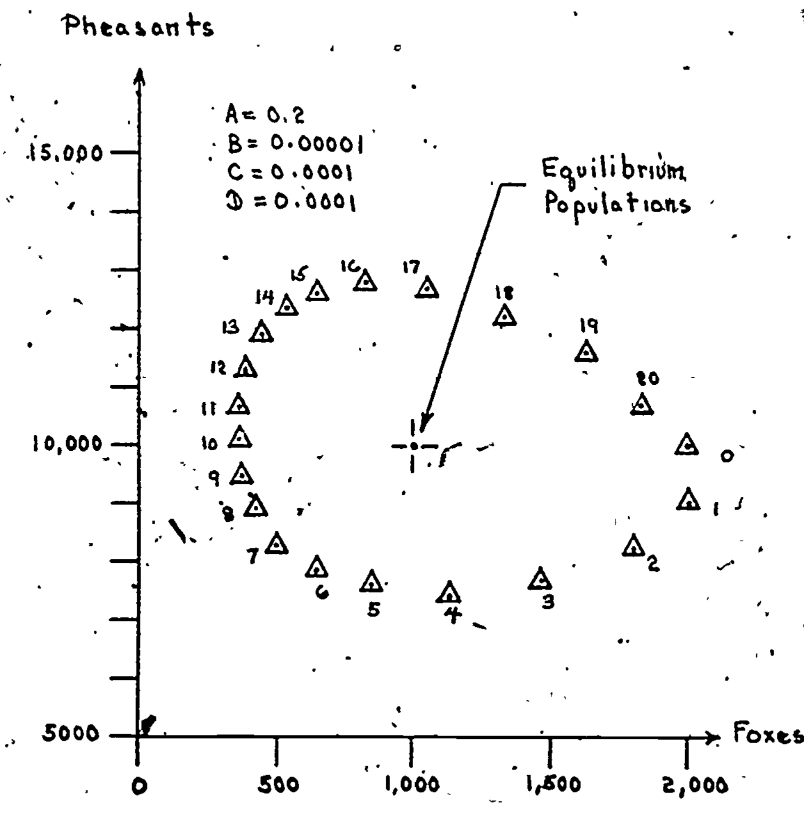

Figure 6 - Predator Population Versus Prey Population

As with the motion example, the advantage of computer use here seems obvious. Students with almost no mathematical skills can be brought into the very heart of a topic. The more traditional approach of demanding analytic solutions requires a mathematical investment which automatically excludes the vast majority of the student population, and most of the really interesting problems. The consequences of this exclusion are seen in most general education courses (biology, physics, economics, etc.) where the appearance of the simplest equation on the chalkboard is sufficient to send most of the class into shock.

With the computer (or pocket calculator) and very simple difference equations students need not deal only with the peripheral issues in a course. The two examples just discussed indicate how dramatically the situation may be changed. Equally good examples could be drawn from any academic discipline. All this is not meant to detract from the utility and value of analytic methods. Hopefully, the case is made that computer or calculator oriented methods should receive at least an equal priority with analytic approaches.

COMPLACENCY: Patterns Of Change. One might be tempted to observe that such a fuss should not be made over the computer since, after all, it is just another tool available to man for his use. That this is most emphatically wrong can be demonstrated quite easily. Let us examine the changes that have taken place in typical activities of mankind since antiquity. For example, suppose we assume that a man could travel about 50 miles on the average in a day in antiquity. Today, a man can travel 10,000 miles in a 24 hour period using commercial jet schedules. If we take the logarithm to the base 10 of the ratio 10,000 to 50 we obtain 2.3 orders of magnitude change. In antiquity, the energy available to the average man must have been of the order of 10 kilowatt hours per day. The percapita energy consumption in the United States in 1970 was approximately 240 kilowatt hours per day. This represents 1.3 orders of magnitude change, certainly quite a bit less than the change in transportation. The life expectancy in antiquity was about 20 years. Today it is about 70 years, or an order of magnitude change of about 0.5. Viewed in this light, there has certainly been much less change in life expectancy than in either transportation or available energy.

Now, we turn to computational speed. For want of a better standard, let us use the ability to multiply two eight digit numbers together. To test this I multiplied two eight digit numbers together with pencil and paper where the digits in the numbers were selected at random. It took 4.5 minutes to complete the calculation (which incidentally turned out to be incorrect when checked with a pocket calculator). If about the same capability existed in antiquity, a man could do about 0.05 of these calculations per second. A modern high speed computer could do at least ten million such calculations each second without error. This represents between 8 and 9 orders of magnitude change.

Nine orders of magnitude change in a capability represents an enormous change. The computer is not just another tool. This becomes even more important when we pause to consider that we really are talking about processing information of all types, not simply multiplying numbers together. It is probable that the most serious mistake that can be made is to base critical decisions on traditional premises which have always been true, but which have (possibly unnoticed) changed. History is full of examples of the unexpected and tragic results which can follow such mistakes.

It seems clear that the computer revolution represents just such a fundamental change. However, with precious few exceptions it is "business as usual" in our classrooms. There simply have not been changes in content or approach that in any way match the unbelievable chance for change made possible by the computer.

Opportunity For True Innovation. True innovation should not be confused with relatively minor changes in classroom procedures. We are all familiar with faddist innovations that quickly fade into obscurity True innovation may be a great deal more difficult to achieve than we can imagine at the present time. However, this shouldn't detract from the value of the results if they can be obtained.

Ultimately, of course, we come back to the individual teacher and what motivates him. Merely to state a logical cause is not enough to make the academic world flock to the side of reason. The "true believer' often becomes terribly impatient when his cause is not immediately adopted. Computers are no exception to this. What this does mean is that while investigating the capability of the computer in the classroom, we must not lose sight of the fact that a teacher (possibly not a "true believer" initially) must ultimately carry the results into the classroom. We must give equal attention to what will motivate this teacher to become involved in the process and contribute his skills and energy.

A Prescription. The prescription seems simple enough. The educational profession must find somewhere the courage to critically examine the whole spectrum of educational activities keeping in mind the enormous capability of computers at the present and some estimate of what will be possible in the future. Out of this process must come constructive and far reaching recommendations for change. Whether this can be done or not, and whether the recommendations can be implemented is uncertain. Certainly the track record of the "new math" and the "new physics" is no cause for optimism. However, to sit still and do nothing is the worst possible course of action.

CONCLUSION: We have at hand an unparalleled opportunity to make unprecedented constructive changes in the educational process. In some fashion not yet completely defined the computer must certainly play a pivotal part in these changes. The prices of computer capability are continually dropping. The primary barrier to change seems to be academic inertia. The opportunity is now! What will happen remains to be seen.

COMPUTER USAGE
IN THE COLLEGE CREDIT
HIGH SCHOOL BIOLOGY CURRICULUM

Robert Slaby
Beverly Hills High School

One of the primary objectives of the upper division biology classes at Beverly Hills High School is to prepare students for the rigorous college curriculum in the life sciences. The three classes, Advanced Placement Biology, Advanced Physiology, and Advanced Botany have all been developed to meet the requirements of the college-bound science student. The purpose of the Advanced Placement Biology course is to prepare students for the Advanced Placement Examination offered by the College Entrance Eximation Board of Princeton, New Jersey. If the student passes this examination, he is exempt from first-year biology at most major colleges. Upon completion of Advanced Botany and two essay-examinations a student will receive a year's college credit in Botany from the University of California at Berkeley Extension. In light of this, our staff feels obligated to offer demanding biology classes that will offer the same material as a typical college course. The areas of investigation include biochemistry, energy transformations, cell anatomy and physiology, Mendelian genetics, chemical genetics, development taxonomy, evolutionary process, nutrient procurement and processing, gas exchange, internal transport, cellular respiration, hormones, nervous control (neuron and ANS) and ecological relationships among living organisms. Extensive college-level laboratory experiences using appropriate apparatus and techniques are integrated to provide an introduction to an exemplification of, and reenforcement of the topics presented in the discussion and lecture material. However, we feel that there are experiments that cannot be performed accurately for want of time and equipment in the classroom. It is possible to simulate the action of any organism or group of organisms on a computer, and with the addition of the Hewlett-Packard 2000 ACCESS Series, we feel we now have this capability. All the programs on the System are in the BASIC language. Although this is a rather simple language, it can be easily taught to the students without requiring any special prerequisites or additional course work and within a few weeks nearly all students are able to develop their own programs in which to enhance their own learning and enjoyment.

Computer programming at Beverly Hills consists of four main types. First is Unit Review. The instructor's lecture is typed on to the System with key words omitted from the program. When the student runs the program, he must supply the correct answer in order to complete the program. If a wrong answer is inputted, the correct answer is supplied by the program after two attempts. We feel that this type of programming offers two significant advantages. If a student is absent from a lecture, he can easily receive a copy of the instructor's lecture and, secondly, the program serves as an excellent review for the student who has thoroughly studied the material. A second type of programming is the Self-Test. After the completion of each unit and before the examination, a series of typical multiple-choice or fill-in test questions are programmed on to the System. The student is then allowed to take this "pre-test" to determine what areas require further study. Whenever possible, a page number from the required text is supplied for quick reference for a mistaken entry.

The third type of programming is analysis of laboratory data. Many times it is both impractical, as well as time-consuming, for the student to do the simple mathematical calculations required to determine if his experiment is proceeding correctly. Often experiments have had to be postponed or cancelled to allow the student time for these calculations. Thus, a simple computer program is developed to perform these calculations and allow the student to continue with his experiment. A program which will verify results from a genetics experiment through the use of Chi Square is an example of such programming. A student must know the basic structure of Chi Square in order to input the data, but now is not bound by the mathematical calculations.

The fourth type of programming and the one most fascinating, I believe, to the student and the instructor is the Simulation of Life Processes. Many experiments, due to locality, lack of sophistication of laboratory equipment, complexity in measuring the biological process, and time required for the experiment could not be completed in the lab. The reenactment of Darwin's finches or the Lock and Key Enzyme model in biochemistry are typical examples of these biological simulations.

The second portion of this paper deals with one such simulation developed to allow the student to observe and investigate quantitatively the biochemical processes that occur in nature. With SPHOTO the student is able to simulate the process of photosynthesis in a leaf by inputting varying amounts of carbon dioxide, water, temperature, color of light, and light energy and determine their effect on photosynthesis in terms of the production of glucose, oxygen, and water. The values are in milliliters for carbon dioxide, oxygen, and water; Celsius for temperature, photons for light energy, and grams for glucose. (Please see enclosed computer print-out.

The first stage of the program prints a brief introduction to the actual biochemical processes in photosynthesis, as well as instructions on how to input the experimental data. If the student does not wish to vary any of the above-mentioned physical or chemical factors, the program will print out the results of a standard run which the student can designate as a control for further investigations. The program then asks the student if he wishes to change any of the factors. The operator can change one or as many factors as he wishes to investigate.

If values are changed, the program then types out the new-results based on the inputted data. At this point the program prints out the number of actual photosynthetic cycles and then determines which of the factors eventually limits the rate of photosynthesis.

This simulation is applicable at all levels of high school botany, including Advanced Placement Biology, or first-year college botany. A worksheet with suggested activities and problems has also been developed to accompany the program.

In conclusion, it is felt that the computer, through unit review, self-tests, analysis of laboratory data, and simulation of biological activities has added a new dimension to our upper division classes and has made biology both academically challenging and stimulating to the contemporary student.

TYPICAL PROGRAM PRINT-OUT
(Student Responses Are Underlined)

```
SPHOTO

DO YOU WANT INSTRUCTIONS ? (TYPE
YES OR NO)
?YES
THIS PROGRAM DEALS WITH THE PROCESS
OF PHOTOSYNTHESIS.
IN PHOTOSYNTHESIS CARBON DIOXIDE
(CO2) AND WATER (H2O) IN THE PRESENCE
OF LIGHT PRODUCES SUGAR (C6H1206),
OXYGEN (O2) AND WATER (H2O). THE
OVERALL EQUATION FOR PHOTOSYNTHESIS:

  6CO2 + 12H2O -----> C6H1206 + 6O2 + 6H2O

IN THIS EXPERIMENT YOU WILL BE ABLE TO
VARY THE COLOR OF THE LIGHT USED,
INTENSITY OF THE LIGHT, TEMPERATURE,
AMOUNT OF CARBON DIOXIDE AND THE
AMOUNT OF WATER.

THE PROGRAM WILL TELL YOU HOW MUCH
SUGAR, OXYGEN, AND WATER IS BEING
PRODUCED AND WHAT FACTOR EVENTUAL-
LY STOPPED THE REACTION
(THE LIMITING FACTOR).

A TYPICAL EXAMPLE WOULD BE:
FOR EVERY 134400 ML OF CO2, 216 ML
OF H20 AND 48.16*10↑23 PHOTONS OF RED
LIGHT AT 20 DEGREES CELSIUS THE
FOLLOWING IS PRODUCED:
GLUCOSE: 180 GR
OXYGEN: 134400 ML
WATER: 108 ML

NOW YOU MAY TRY THE ABOVE EXPERI-
MENT BY VARYING ANY FACTOR THAT
YOU WANT. IF YOU DO NOT VARY A FACTOR
THE FOLLOWING VALUES WILL BE USED:
134400 ML OF CO2, 216 ML OF H2O, AND
48.16*10↑23 PHOTONS OF RED LIGHT AT
20 DEGREES CELSIUS. YOU MAY VARY
A FACTOR BY TYPING IN THE NUMBER
ASSOCIATED WITH THE FACTOR.
  #1 CARBON DIOXIDE
  #2 WATER
  #3 COLOR OF LIGHT
  #4 LIGHT INTENSITY (PHOTONS)
  #5 TEMPERATURE (CELSIUS)

WHICH FACTOR DO YOU WISH TO VARY ?
IF YOU DO NOT WISH TO CHANGE ANY-
THING TYPE A 6
?6

AMOUNT OF GLUCOSE PRODUCED:
180 GR
AMOUNT OF OXYGEN PRODUCED:
134400 ML
AMOUNT OF WATER PRODUCED:
108 ML

THE PLANT RAN OUT OF WATER

THE PLANT RAN THROUGH THE PROCESS OF
PHOTOSYNTHESIS 3.01000E+23 TIMES.

DO YOU WISH TO RUN THE EXPERIMENT
AGAIN ? (TYPE YES OR NO)
?YES
WHICH FACTOR DO YOU WISH TO VARY?
IF YOU DO NOT WISH TO CHANGE ANY-
THING TYPE A 6
?3
WHICH COLOR OF LIGHT DO YOU WANT TO
USE
  #1 BLUE
  #2 GREEN
  #3 YELLOW
  #4 RED
?2
WHICH OTHER FACTOR DO YOU WISH TO
CHANGE?
TYPE 6 IF YOU ARE THROUGH
?6

AMOUNT OF GLUCOSE PRODUCED: 60 GR
AMOUNT OF OXYGEN PRODUCED: 44800 ML
AMOUNT OF WATER PRODUCED: 36 ML

PHOTOSYNTHESIS HAS STOPPED BECAUSE
THERE IS NOT ENOUGH LIGHT (PHOTONS).

THE PLANT RAN THROUGH THE PROCESS OF
PHOTOSYNTHESIS 2.00667E+23 TIMES.

DO YOU WISH TO RUN THE EXPERIMENT
AGAIN ? (TYPE YES OR NO)
?NO

DONE
```

SPHOTO LAB WORKSHEET

It is possible to simulate the action of any organism on a computer. In this lab you will simulate the process of photosynthesis in a leaf. You will be able to vary the amount of carbon dioxide, water, color of light, and light energy and determine the effect on photosynthesis. As you complete the lab on the computer, please answer the following questions:

1. a) Holding all other values constant, if equal amounts of water and carbon dioxide are supplied to a plant, which will limit the rate of photosynthesis?

   b) In what ratio should the carbon dioxide to water values exist for a plant?

2. a) What color light is best for photosynthesis?

   b) Why do you think this is so?

   c) Rank the other three colors in order of efficiency.

3. Would supplying twice the amount of light double the rate of photosynthesis? Why or why not?

4. Calculate the amount of sugar, oxygen, and water produced during one complete cycle of photosynthesis.

   (Hint: $\frac{\text{amount of glucose produced}}{\text{number of photosynthesis cycles}}$

5. Construct a graph illustrating the effect of temperature on photosynthesis.

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A MINICOMPUTER - MICROCOMPUTER HIERARCHY FOR REAL TIME EXPERIMENTS

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ABSTRACT: Microcomputers are ideal tools for conducting real-time computer controlled experiments. Their low cost allows computer power to be dedicated to a single experiment simplifying programming and speeding laboratory experiments. Additional advantages are portability and conceptual simplicity.

Several severe handicaps are associated with microcomputers. Limited ability to compile high level languages requires compilation on a larger computer. This is cumbersome and time consuming. A second problem is the cost of mass storage which has not declined. A computer network is described that uses an HP 2100 minicomputer with a number of microcomputers to make use of the most advantageous characteristics of each type of computer.

Microcomputers are ideal tools for conducting real-time computer controlled experiments. Their cost allows computer power to be dedicated to a single experiment simplifying programming and speeding laboratory experiments. Additional advantages are portability and conceptual simplicity.

Although microcomputers are inexpensive tools for real-time computation, they have been difficult to program for a number of reasons. First, usually the only alternative available has been assembly language programming. Except for PL/M no compiled high-level language is available. Although BASIC is available, it tends to slow the microcomputer as well as require more memory than assembly language.

An associated problem is program development and debugging using a minimal system, probably with only teleprinter I/O. This is a painful and time consuming process interfering with creative thought and tieing up valuable capital equipment. To support the editor and assembler the microcomputer must often have much more memory than the application program requires. Attempting to speed the assembly process and/or implement a higher level language necessitates comparatively large expenditures for memory and mass storage.

The advantages of a microcomputer are its low cost and conceptual simplicity, both conducive to extensive student experimentation. The disadvantages are the difficulty of programming the microcomputer and lost time for creative activities caused by lack of suitably inexpensive mass storage device. Minicomputers do not have the aforementioned disadvantages and it seems reasonable to combine mini and microcomputers in a network to gain the advantages of both while minimizing their disadvantages.

A computer network under construction at the University of Colorado, Colorado Springs uses an HP 2100 minicomputer in conjunction with a number of microcomputers to make use of the most advantageous characteristics of each type of computer.

The minicomputer's editor program and disk and tape storage facility provide ideal working tools for developing microcomputer software. In addition, giving the minicomputer the task of language translation considerably reduces the pressure for large amounts of microcomputer memory.

Two kinds of microcomputer stations are under development. The first kind connects to the HP 2100 via a 2400 baud serial link. This interconnection allows the minicomputer to load and dump the microcomputer's memory as well as insert breakpoints and act as a debugging tool. A teletype or other terminal located at the microcomputer station allows the operator to communicate with the 2100 or directly with the microcomputer. The operator programs in a high-level language; the first being developed is an application-oriented language for an analog-hybrid computer interface. The operator experiences the characteristics of a minicomputer when editing or compiling but experiences the attributes of a microcomputer when programming, debugging or running.

A second kind of station communicates with the minicomputer only by the exchange of magnetic media. We are currently developing a microcomputer system dedicated to performing a real-time instrumentation task. User programming will be accomplished by single key-strokes in much the way a calculator is used. About half a dozen micros are incorporated in this instrument. A cassette tape drive will allow its data files to be read by the 2100 for complex processing unavailable on the single keystroke system. Although not physically interconnected to the 2100, we consider this kind of microcomputer system to be integrally part of our "network".

An example of the first kind of microcomputer station is a microcoputer controlled analog-hybrid computer. This is currently being implemented at the University of Colorado using a Motorola M6800 microcomputer to control a Hitachi 505 analog computer. Those attributes of this microcomputer station that are universal in concept will be discussed here. Specific needs of the analog-hybrid system will be addressed at some later date.

Several design goals were set for this microcomputer station. These are:

1. Inexpensive and simple construction that is easily repaired and easily duplicated.
2. Off-the-shelf multiple-sourced components wherever possible.
3. Simple and logical operating procedures requiring little knowledge of computers.
4. Un-compromised capability for operators with a great deal of computer experience.
5. Sufficient initial and expansion capability for a wide range of tasks.

Although this set of goals seems very modest, we felt that these were sufficient to insure excellent utilization of the equipment for all users from "beginning" students to "researching" professors. As it turned out, these goals were difficult to meet simultaneously.

In particular, goal 3, simple and logical operating procedures, was difficult to meet while providing extended capabilities for experienced operators. The central problem was that the operator had to concern himself with two computers, the M6800 and HP2100, and he had only one terminal with which to accomplish this. One alternative would have been to connect the operator's terminal directly to the M6800 and connect the 6800 directly to the 2100 as shown in Fig. 1.

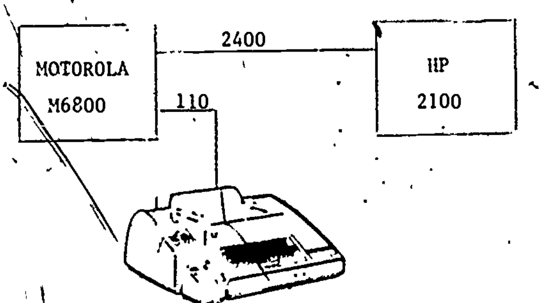

Fig. 1 Direct Connection

The control program in the 6800 would allow the operator to communicate with the 2100 as required through the microcomputer. This control program must reside in ROM to avoid a complicated manual bootstrap (remember those inexperienced operators). Although this could have been accomplished by having a PROM programmed for us, we felt this approach had several disadvantages. Functional system characteristics would be specified in the PROM program and difficult to change as the need arose and would be impossible to change dynamically. debugging control would be in the hands of the microcomputer with limited capability. The possibility of a berserk program disabling the debugging routine must also be considered.

A second approach considered was to switch the terminal, microcomputer and minicomputer interconnections as shown in Fig. 2

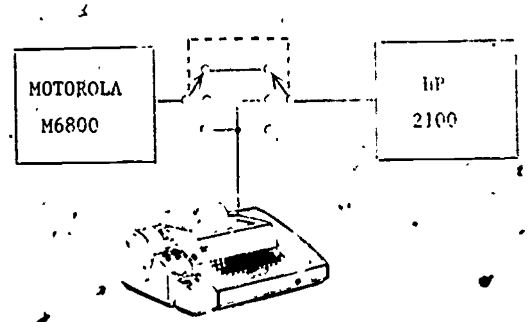

Fig. 2 Switched Connection

Control of the switch presents some problems. A manual switch would be cumbersome and difficult for inexperienced operators to use. It would be desireable for an automatically controlled switch to be controllable by both the 2100 and microcomputer depending on the task being performed. This complicates the hardware, especially that hardware used to give the 2100 switch control. Finally, either the baud rate of the serial interconnection must be made dynamically alterable or we must rule out teletypes as a suitable terminal. It would be intolerable for program loads or other data passing between the two computers to be limited to 110 baud.

Finally, after much soul searching, the configuration of Fig. 3 was adopted.

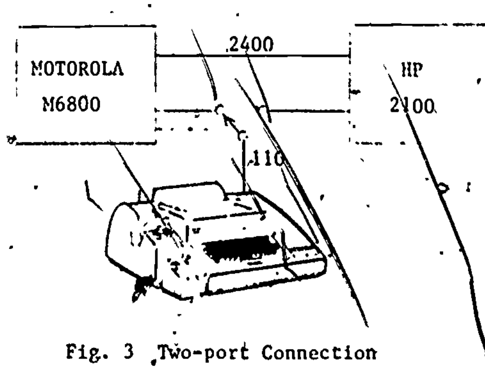

Fig. 3 Two-port Connection

A 2400 baud direct interconnection is made between the two computers for down-line loading of the microcomputer, debugging of the micro's program by the 2100, and for data transfers between the 6800 and 2100. The operator communication terminal is switched between the 6800 and a second port on the 2100 under control of the 6800. This switch may also be controlled by the 2100 during program load and debugging operations. The M6800's peripherals including this terminal's switch are treated as memory locations. Hence the 2100 can easily modify and read peripheral status via the 2400 baud direct interconnection and thus control the terminal switch.

In operation, the 2100 is normally left running continuously. When the M6800 is powered-up, the terminal switch automatically aligns itself to the 2100 position to allow the operator to log onto the 2100. The operator may then write, edit and compile programs using the 2100. An M6800 loader program running on the 2100 allows down-line loading of the microcomputer. This loader is written to be compatible with Motorola's MINIBUG™ loading and debugging program which is available as a standard ROM. The 6800 is initialized on power-up to run this loading program.

As part of the loading process, the operator may or may not specify that the terminal be transferred to M6800 control. Debugging is accomplished with the terminal connected to the 2100. A debugging program on the 2100 communicated with the 6800 via the direct interconnection and the MINIBUG™ program running on the microcomputer. This allows the 2100 to do number base conversions, simulate multiple breakpoints and perform other debugging functions not available with the MINIBUG™ program.

The operator need only give commands to edit, load, compile, debug, run, etc. without regard for the computer in which the operation is to be performed. The only fixed program in the microcomputer is the debugging ROM which is a simple absolute loader, dump and breakpoint routine. In addition, a dedicated high-speed interconnection to the minicomputer is always available regardless of the state of the operator's terminal. We feel this is sufficiently flexible for any future applications that arise.

The rest of the microcomputer system is fairly straightforward as shown in Fig. 4.

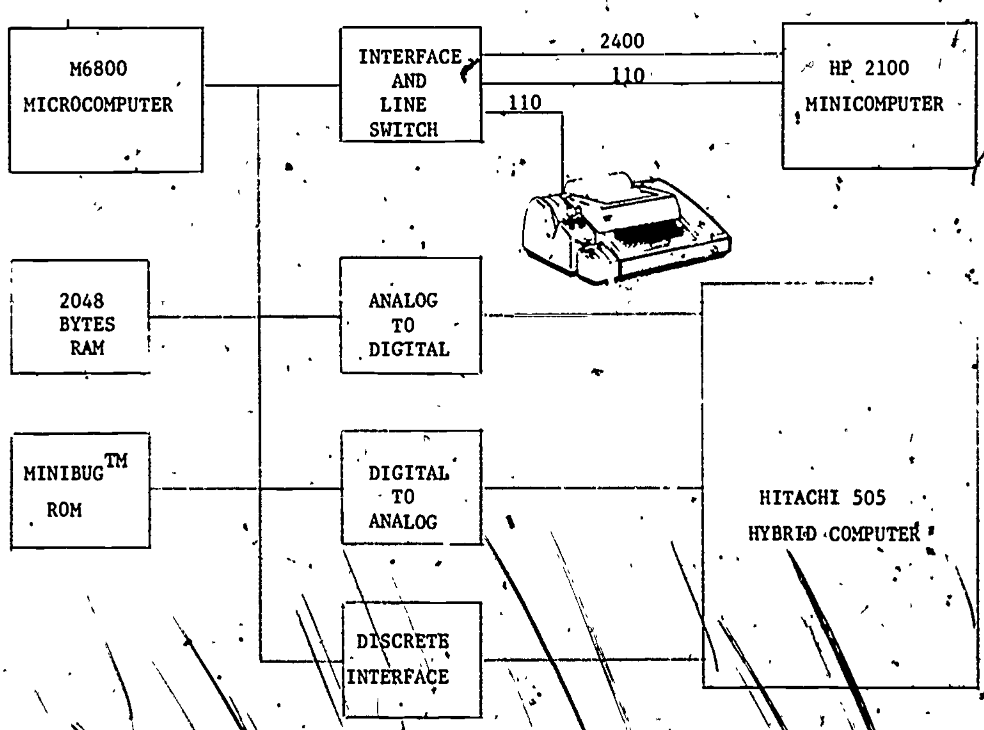

Fig. 4 Hybrid Computer Interface

It is constructed in a rack-mounted card file with appropriate power supplies. External I/O connections are made to screw connections on the rear of the various cards. Peripherals include an 8 channel differential input analog-to-digital system and a 4 channel analog output system built with off-the-shelf (Burr-Brown) converters. Sixteen discrete output channels are open collectors capable of 15 Volts and 300 ma. Sixteen discrete input channels have schmidt-trigger conditioned inputs. Random-access memory initially available for user programs is 2048 bytes.

Besides the basic control software for the 2100, including a cross assembler, down-line loader and debugging program, we initially plan to develop a block-diagram oriented microcomputer simulation language. This would allow the analog computer to be used in conjunction with the microcomputer for experiments in real-time control.

The second kind of microprocessor station, transferring data only by magnetic media, has design goals quite different from those discussed above. Equipment and function is very specific. Simplified operating procedure is stressed at the expense of flexibility for sophisticated users. Since users have little need to know internal details of the microcomputer, advanced techniques are perfectly acceptable and probably desireable. The major design goal is to supply a piece of equipment that would assist in engineering design. Transfer of data via magnetic tape to the minicomputer is the only concession made to increasing flexibility. This allows data gathered by the microcomputer to be processed by the minicomputer for additional analysis only if desired.

The system being constructed consists of a microcomputer and appropriate peripherals to measure and manipulate parameters of semiconductor devices as shown in Fig. 5. Single keystrokes measure, manipulate, and display parameters much like single keystrokes call up functions on a calculator. Although requiring no computer ability, this approach allows large amounts of computer power to be used by students studying various disciplines. Relieving students of large amounts of arithmetic drudgery enables more creative work to be incorporated in the limited time available in a single course. The current trend in the elctronics industry to utilize more automated instrumentation and procedures in design affirms the need and usefullness of this approach.

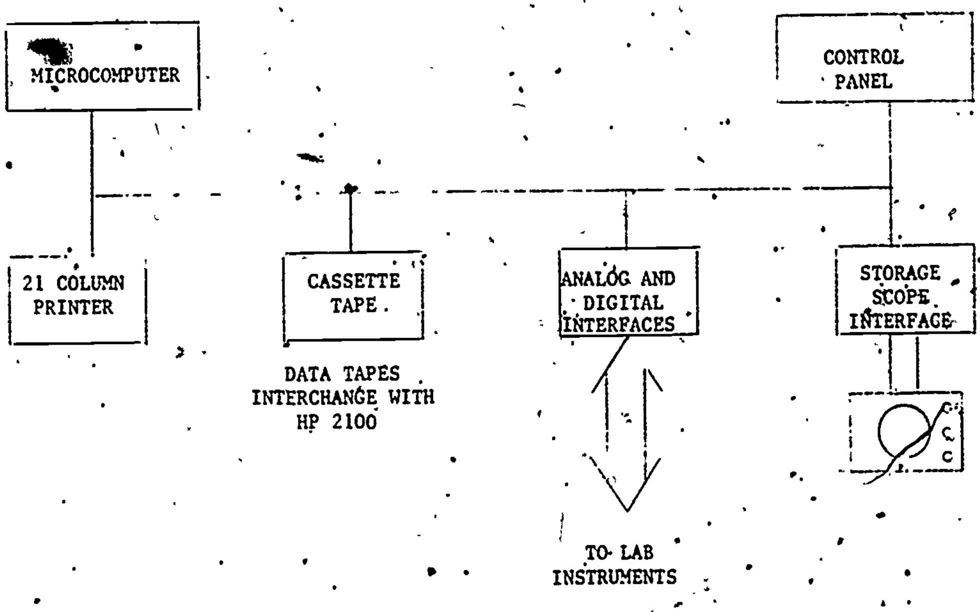

Fig. 5. Dedicated Microcomputer

INTRODUCING THE COMPUTER INTO TEACHER EDUCATION:
AN INTEGRATION OF HUMAN AND HARDWARE TECHNOLOGY

Ray Muston and Rita Wagstaff
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In the summer of 1973, the University of Iowa began a 2-year pilot study of the effect of interactive computing on undergraduate instruction.

A Hewlett-Packard 2000F interactive mini-computer system was purchased by the University of Iowa and 8 of its 32 ports were allocated to the College of Education.

A faculty Advisory Committee, newly created by the College of Education, established the following objectives:

1) To facilitate faculty development of C.A.I. materials.
2) To encourage essential software development
3) To provide maximum opportunity for students to interact with a computer system as a regular part of their instruction.

Activities directed toward achieving these goals, and methods of education will be discussed.

PUBLICATION OF A COMPUTER COURSE: A CASE STUDY

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ABSTRACT. Many instructors develop course materials for their own classes and, finding them successful, are eager to seek publication. An author's first question is how to contact a publisher. This paper describes some successful approaches along with further steps in the process toward final publication. The author's responsibilities are stressed especially in identification of sources, checking of illustrative materials, and verification of content. The particular course used as an example is the audio-tutorial course, COMPUTER PROGRAMMING: AN INDIVIDUALIZED COURSE IN FORTRAN IV.

My paper today concerns the process of getting a program, which you have developed and used successfully, out into the world where others can take advantage of your expertise, and you can reap some reward from all your hard work. How do you find a publisher or other marketing group to make your program or course available to the wide audience for whom you think it is suitable. Now there are many questions a would-be author has involving publication, and I will try to anticipate as many as I can. My talk will be short, so that I can try to answer any questions you still have at the end of the formal presentation.

I want to start with the very early stages of getting something published. To illustrate, I will use two different programs. One is a course titled COMPUTER PROGRAMMING: AN INDIVIDUALIZED COURSE IN FORTRAN IV, which we at Westinghouse Learning Press have recently published in tape and text form. The other is not a printed text, but an actual computer program which we hope to make generally available. Let me explain what happened in the beginning with each of these programs, how I became interested in them, and how they moved to final production. At the same time, I will also use as examples, but not mention by name, other programs or proposals that I have rejected. I will also talk about why I held some for a time before making a final decision.

I think there are three questions that are important here from your point of view. 1. How do you make a contact to start the very first steps toward publication? 2. How long is it going to take before your material is accepted and how long for it to reach the light of day through publication? 3. Finally, how much money will you get and when are you likely to begin to receive it?

First of all, I would say there are a thousand different ways to make a contact. Some are extremely effective and some are not. You are in the position of selling something, and most of the well known tips on selling apply to getting a manuscript accepted. If you teach in a college or university you probably realize that some of the college travellers who come around to sell texts are also on the lookout for courses or materials to publish. Thus contact with a sales representative may make a good first step. On the other hand, some sales reps are not particularly interested in follow-up on manuscripts. They will encourage you, but if they do not suggest a specific second step, you may be at a dead end. Some publishers give credit to salesmen for the number of potential manuscripts referred to the editorial department. In some cases the college travellers are acquisition editors who combine the task of selling with the task of acquiring materials. Try to learn the name of an editor back at the home office to whom you can write directly.

Another way to make contact is by letter. Like all direct mail, your letter has to sell something. Few publishers want to buy you--so concentrate on describing your product rather than yourself. A letter of inquiry with an outline of what the author has in mind is usually answered promptly, but promptness is directly related to how far along the project sounds and how well it is described. The editor usually sends you a series of questions whose answers will serve as a guideline both for you and for the publisher in assessing the potential of your manuscript with that particular publisher. Let me suggest, though, that you do some homework before writing. Does the publisher you are approaching have a list of courses similar to yours? Obviously a college publisher is not usually interested in elementary school material. Some publishers are strong in a particular discipline. Others specialize in multi-media approaches. Learn your market in advance.

From time to time I get telephone inquiries from people who have seen one of our courses and want to publish with us. My response to telephone inquiries is the same as to a letter. I ask for an outline, prospectus, and usually a sample.

Notice that all of the queries that I have mention involve some sort of personal contact. If you write or call, it never hurts to mention the name of a college traveller who may have talked with you.

Often people don't want to take the time to make contacts one by one or the trouble to find a name, or even a title. I get many letters which come in on mimeographed or photocopy paper; sometimes our company name is not even typed in at the top of the letter. Needless to say, this kind of submission goes to the bottom of my consideration pile; I don't pay a great deal of attention to such inquiries unless, and there is a big unless, the material is something that I am really looking for at that very moment or sounds so exciting that I can't bear to pass it up. At the very least, take time to type in the address and a name, or a title at least, for each company to which you are submitting material.

Where can you get such names? Most of the major publishers are listed in the Literary Marketplace, and there are other reference volumes where you can usually find a managing editor, or an editor-in-chief, or an acquisitions editor listed. Any of these titles are good to use if you do not have a specific name.

What was the contact for COMPUTER PROGRAMMING: AN INDIVIDUALIZED COURSE IN FORTRAN IV? It actually was referred to me by a representative from another company. The authors had already submitted their course to a publisher, but it was moving extremely slowly. It was designed as an audio-tutorial course, and the editor who had signed the author moved to another company. The publisher became reluctant to get into the audio field. A second publisher's representative heard the authors describing their problems and suggested that the authors request a release. Knowing our interest in audio courses, he called and asked if it would be useful for them to submit the material to me. Let me hasten to add that I did not even look at the material until they had a release.

Let's look at another successful contact, the actual computer testing program I am working on now. The author and the programmer sent me a well-written letter describing their program. Their clear description led me to telephone them immediately.

Now how long does it take? So much depends on the shape of your material in the first place. Publishers are not keen to get complete unsolicited manuscripts. On the other hand, in a couple of cases, where I have had a complete manuscript sent, I have immediately called the author, and we reached an agreement in much faster time than if we had gone through some of the traditional initial steps. I just suggest that you write as descriptive a prospectus as possible, and that when you get a letter asking questions or asking for a detailed outline and sample material, send it in as fast as you can. A quick response gives the editor an opinion of your ability to deliver the product.

We receive many program samples that include tapes. I do not like to review tapes, and since most publishers are primarily interested in the content of the tapes you will do better sending a transcript rather than the tape itself.

After the editor decides that your project may have potential, the editor usually has to get an outside review of your sample or manuscript. In addition some market research must be done to determine the potential value of this particular course. The editor also has to find out how much this particular course is going to cost to produce and how much it is likely to bring in in revenue. Finally, the editor, along with a group of decision makers in the company, decides whether it is appropriate to put you under contract.

During this period you can be of help in providing some marketing information. You may know more about the competition than the editor or the marketing director and such information, if accurate, is gratefully received. You may also have insight into trends in your field. If your institution can be expected to adopt your course, that is important, too. Guaranteed sales of a couple of thousand copies can be a big influence in the publisher's decision.

During this time you should also get started on clearing rights to the material if you have not already done so. I cannot overemphasize the need for clearing rights at the earliest possible stage. If you have prepared material under a government grant, or if you have prepared it under released time from your institution, or if you have used institutional facilities, you should make very certain that you have free and clear rights to this material. Some colleges and universities are setting up rigid copyright procedures, and it behooves you to check your college policies in this matter. Such policies are seldom included with your teaching contract or letter of agreement. The letter usually implies that you will abide by the policies of the college, and often these policies are not gone over with you individually. You usually get a fat pamphlet that you glance over and do not refer to again until problems arise. At the same time, however, do not be alarmed if your college has certain restrictions. These are usually reasonable and workable.

Again let me emphasize the need to get clearance early. Many people are very willing to give you a release when you say, "I hope to publish this material some day." They become much less agreeable or generous as soon as there is an indication that the venture may be profitable. Your publisher may be able to help you in working out problems, but if there is any possibility that someone has vested rights, get clearance at the start. If you have graduate students working for you at anytime, you should always obtain clearance from them for the work done as part of a stipend or grant. An acknowledgment, of course, is always courteous. Sometimes the publisher may give a small advance against royalties to smooth the way in obtaining these full rights. Other times you may have to give a colleague, an assistant or the institution a share of your royalties. In terms of clearing rights, I would like to mention that some states do have laws whereby an instructor at a public college cannot profit from sale of his or her own material at that college. The instructor can use these materials for a class but is not entitled to receive royalties. If there is a chance that you fall into this category, research the legal ramifications early. Remember, also, that you are responsible for providing other aspects of clearing acknowledgment through footnotes, permission from the copyright holder for lengthy quotations and for use of illustrations. Although your publisher may give help in these areas, they are the basic responsibility of the author. Some clearances, of course, can wait until after the actual work has begun.

Suppose, though, that all has gone well, and you do sign a contract. Here comes the big question, how much money are you likely to get and when? This question is difficult to answer because it varies so much from publisher to publisher. Some publishers have a stock percentage for all contracts. Some negotiate each contract separately. Right now, there seems to be a big backlog of manuscripts for publication; so many, that royalty rates, which were on the rise, are now stable, if not declining. Where advances were given quite freely 5 to 10 years ago, many publishers now pay very small advances or none at all. Often the advance is given only to cover such items as permissions, illustrations, subject matter consulting, and possibly typing assistance. Let me assure you that most first time authors have to work what we call "spec" or speculation. You must prepare and edit your material and do a lot of hard work before you ever see any money.

The percent of royalty is variable from publisher to publisher, and it is not appropriate, in fact I think it is illegal, for me to go into details. You just need to be aware that there are variations in the amounts of royalties paid, for different kinds of rights and for different kinds of sales. There are rates that escalate after so many copies are sold. There are rates that are based on the discounted price of the book, and there are others scaled to the list price of the book. All I can say in this regard is that it is advisable to have a lawyer look at any contract that is offered to you, although even some very good lawyers seem to be unfamiliar with the peculiar terminology that gets into publishing contracts.

The world of publishing is changing rapidly, and different kinds of contracts will evolve. Faced with the possibility under the proposed copyright law that give educational institutions wider access to reproducing, we will have to reexamine many traditional ideas in publishing, contracts among them. In developing a contract, all I can say is that, like many other business transactions, there has to be good faith on both sides. You will be negotiating with an individual who represents a company and you have to feel that you have trust in that person and in that company.

Now how about the monetary rewards? Usually, the first income you receive comes in the semester following the publication of the book; that means that if your material is published any time from July through December, you will receive a report of your royalties about 30 days after the end of that period and payment 30 to 60 days later. Some publishers, however, report only annually; this is an item to check in your contract.

There will three very happy days in your career as an author, one when you sign the contract, the next when you actually hold your publication in your hand; a third when you get your first royalty check. In between the first and second, however, lies a dark period known as the editorial process which goes something like this: If your manuscript is complete to start with, a subject matter reviewer makes suggestions and the material is returned to the author for the appropriate changes. If material is not yet complete, an editor usually works on a submitted sample, a chapter or unit, suggesting format changes and guidelines. The author is then expected to complete the work, usually with ongoing feedback. After the author has made the appropriate changes, this may involve sending the manuscript back and forth several times, and when the editor is satisfied, the manuscript receives what we call copyediting. This process is designed to coordinate and synchronize all the elements. If tapes are being used, the text or workbook must be keyed accurately to the tapes. If there are objectives, evaluation items must be needed to be keyed to them. Consistency of numbering systems, of terminology, of headings, all these are components which the copyeditor checks, along with a basic style of grammar and punctuation.

The next part of the process is called composition--the setting of material into type. Authors are asked to sign off for content on the manuscript stage. Once material is typeset, changes are costly. Obviously, there are always typos; there is always a split infinitive that slips in; a correction was retyped and then was missed by the typesetter; these changes, of course, must be made. But publishers are fairly strict about arbitrary changes that authors make and may charge the author for them. Of course, if an author is willing to pay, and the schedule permits delay there may not be a limitation. At this stage a final check of illustrations is made to make certain that labels and references are correct. Proofreaders scour the galleys for error; the dummy is put together; and production editors make certain that everything is in its proper place. Finally, it all comes together and you are a published author.

What are some of the problems related to publishing that may affect your chances of getting material published? First of all, there is probably too much being published, although the education market is enormous, it has limits. The competition is fierce. Since so many manuscripts are available, publishers can afford to be discriminating about what they select. Rising costs mean that publishers are less likely to take a chance on an unusual book then they were in the days when an edition of 3 to 5,000 meant recovered costs and some profit. Inventory requirements and the high costs of short-runs make a publisher reluctant to undertake a publication unless it can be priced high, or the sales are likely to be quite high in the first year.

On the positive side is the fact that instructors are always looking for new material and for good material. I sometimes feel that they are actually looking for magic material that will solve all the problems of teaching. But one year's magic may be another year's millstone. Students change, instructors change, and society's demands change, so it is important to be realistic about anything you want to try to get published; take a look yourself at what the market place already has to offer. Remember that you have to sell your product to the publisher, before the publisher will undertake to sell it to the market.

I do want to end, however, on an encouraging note--the possibility exists for real success--both critical and financial, but even if these rewards are comparatively small, there is enormous personal satisfaction in being a published author. Why not try?