Minnesota

Project Woksape

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Final Report 1989

IBM Advanced Education Project

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Final Report

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IBM Advanced Education Project

submitted by

The University of Minnesota

Woksape (Wok' sah pee) is the Dakota Indian word for "wisdom," but it is also translated as "knowledge" or "learning." With the specific intent of this project focused on developing new software for instruction and research, our project name not only calls attention to the purposes of the IBM Advanced Education Program, but also acknowledges the important influence that Native Americans have and continue to have on the region we now call Minnesota. Woksape speaks to the importance of continually developing new knowledge and embodies the historical roots of the University of Minnesota as a land-grant institution.

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Executive Summary

Project Woksape has been a joint effort by the University of Minnesota and IBM Corporation to enrich the educational and research environment of the University by introducing personal workstations into the teaching and research of the Twin Cities campus. It began on August 1, 1985, with the announcement by IBM Corporation of its intent to provide $7.5 million of hardware, software, and other support over three years to help faculty plan innovative projects in computer-based instruction. The University of Minnesota was one of 19 universities participating in the Advanced Education Project (AEP) with IBM's Academic Information Systems (ACIS) division.

At IBM's request and with University concurrence, four colleges participated in writing the original proposal: Agriculture, Education, Liberal Arts, and the Institute of Technology. An ad-hoc committee of three senior administrators coordinated the writing and submission of the proposal, and the selection of projects to be included: Richard Heydinger, Sr. Assistant to the President; John Wallace, Assistant Vice President for Academic Affairs; and Barbara Wolfe, Assistance Vice President for Information Systems. Donald R. Riley was named Project Director at the official grant announcement on August 1, 1985. A total of 42 projects were funded in the first year, as defined in the original proposal. In July, 1986, an additional 15 projects were approved, including projects from the General College, College of Biological Sciences, Medical School, School of Nursing, College of Pharmacy, School of Management, and College of Veterinary Medicine. Projects funded in November, 1986 numbered 20 and added participants in the School of Dentistry, College of Forestry, and Law School. With the funding of 16 new proposals in 1987, the total number of Woksape projects reached 93, with participation by 14 of the University's 18 colleges and professional schools. The final round of funding in spring 1988 brought the total to 103 projects.

The University has provided total funding of $3,400,000 for the project. These funds furnish central support for the project, including on-site maintenance of all granted equipment, technical support, assistance in instructional design, programming assistance, required non-IBM hardware and software, supplies, and some faculty summer support.

As new hardware and software have become available from IBM, and as faculty awareness and expertise increased, the needs and specific objectives of the total project, as well as of many individual projects, have evolved. The original proposal projected a total of 445 workstations plus an IBM 4381 mainframe to serve the needs of Woksape participants. The workstations were envisioned to consist mostly of PC/AT workstations, with some PCs and PC/XTs. Approximately 640 IBM workstations have been delivered to the various funded projects, with a retail value of $7.6 million. In addition to the PC/XT/AT workstations, a number of advanced RT PC and PS/2 workstations have been introduced on campus. Plans for the mainframe evolved into an upgrade of St. Paul Computing Services' IBM 4381 to a dual-processor 4381 with additional peripherals, software, and communications. This upgrade was designed to integrate Woksape needs for mainframe services with those of several other groups at the University, in keeping with the strategic plan of Academic Computing Services and Systems (ACSS) to provide a "seamless" computing environment for students and faculty.

Specific results are becoming apparent. Most projects have "finished" software in classroom use or in pilot-testing. Some software has been licensed by the University for commercial distribution and is already producing some revenue for the University. Several software packages and faculty have gained national attention, with at least one package winning a national award for excellence

In conjunction with its Advanced Education Project, IBM supported the establishment of an on-line data base of all AEP projects. The ISAAC (Information System for Advanced Academic Computing) data base at the University of Washington provides summaries of individual software-development projects at all 19 AEP schools. At this date, nearly 1900 project descriptions are accessible through ISAAC. ISAAC also provides access to bulletin-board services. Increasing numbers of faculty use ISAAC, which is offered via an 800 number, to find existing software that will contribute to their instructional-software endeavors.

To promote access to software under development at the 19 AEP institutions for testing and classroom use, IBM established a software-distribution center at the University of Wisconsin. Software distributed through this center is called Wisc-Ware. There are currently over 220 packages available through Wisc-Ware, 27 of which have been supplied by Woksape participants and the University of Minnesota's Microcomputer Systems Group.

IBM support for Project Woksape and the 18 Advanced Education Projects (AEP) at other universities has promoted innovative use of computers in instruction and, thus, the quality of instruction at those universities, far beyond the advances that would have occurred without that support. At the University of Minnesota, Project Woksape served as a major catalyst for focusing attention on the innovative and effective introduction of computer technology into the classroom. As such, the impact of the Project has been much greater and broader than the specific objectives originally proposed. The benefits derived from Woksape will be felt far into the future.

University of Minnesota Overview

The University of Minnesota can be defined in terms of three characteristics: it is an international research university, a land-grant institution, and a metropolitan university. There are few, if any, other institutions in the country that combine these three missions in the same way. The Twin Cities campus, its largest campus, is made up of 18 colleges and offers the full range of academic and professional degrees. The other campuses are in Duluth, Morris, Crookston, and Waseca.

The University is among 50 universities -- 25 public and 25 private -- in the United States that perform more than 80 percent of all federally funded university research in the country, usually ranking in the top 10 in the amount of federally funded research.

Based on the quality of faculty and graduate programs in a number of fields studied in a recent national survey, the University ranked in the top seventeen of all universities and the top seven of public universities. It has set itself the goal of moving into the top five public universities.

The chemical engineering and geography departments on the Twin Cities campus have been rated first in the nation. Other top-rated departments are mechanical engineering (fifth), psychology (seventh), economics (seventh), and political science (tenth).

As a land-grant institution, the University includes in its mission responsiveness to the people of its region: their education, their health, their economic well-being, and the stability of their society. Because the University is situated at the center of a region with a rapidly expanding high-technology industry, one major need is to prepare highly qualified science and engineering graduates who can contribute to this industry.

The location of the University's largest campus in a metropolitan area presents unusual challenges and opportunities. The Twin Cities campus serves a large proportion of commuting students and part-time and extension students, and serves the educational needs of minority groups who live in the cities. The urban area is also a laboratory for learning, where class projects can be linked with local industries and cultural organizations.

The University is the primary center in Minnesota (and parts of the surrounding region) for instruction and research in the health sciences, law, engineering, agriculture, and forestry: it offers all of the graduate-level programs in these fields. In all the arts and sciences and in teacher preparation, the University is the only doctorate-granting institution in the state. Students may earn undergraduate and graduate degrees in more than 250 fields of study.

Enrollment was 42,571 on the Twin Cities campus and 54,517 in the five-campus system in Fall Quarter 1988. When evening students are counted, the Twin Cities campus ranks most years as the largest single campus in the country. The University community also includes 18,000 faculty and staff members.

The University has a broader range of programs than most other universities in the country. Besides the core programs in the College of Liberal Arts, the Institute of Technology, and the College of Biological Sciences, it has five colleges in the health sciences (Medical School, School of Dentistry, College of Pharmacy, School of Nursing, School of Public Health), three other professional schools (Law School, School of Management, College of Education), four colleges in an agricultural cluster (College of Agriculture, College of Forestry, College of Home Economics, and College of Veterinary Medicine), the Humphrey Institute of Public Affairs, the Graduate School, the General College, and University College.

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Project Office Report

Renee A. Holoien, Administrator
Donald R. Riley, Director

Project Administration

The project was under the general direction of Donald R. Riley, a member of the Mechanical Engineering faculty serving also as Director of Project Woksape. The Project office reported to V. Rama Murthy, Vice Provost and Associate Vice President for Academic Affairs. Since July of 1987, Renee A. Holoien has served as Project Administrator.

Earl Schleske, a Micro-Group manager, served as half-time Technical Coordinator for the project. On-site IBM technical support was provided and coordinated by Al Becker and Robert Heggestuen, full-time IBM employees.

Policy recommendations, and review and assessment of grant proposals were made by the Project Woksape Advisory Committee which, in addition to the project director, consisted of the following members:

Jean Cameron, College of Liberal Arts
Carol Carrier, College of Education
Herschel Ginsberg, College of Biological Sciences (no longer at the University)
Russell Hobbie, Institute of Technology
Mary Marshall, IBM
Keith Wharton, College of Agriculture
Shih-Pau Yen, Academic Computing Services and Systems (ACSS)

Support for Woksape Projects

Technical Issues

Project Woksape was fortunate in that an organization for technical support of microcomputer hardware and software was already in place at the University in the Microcomputer and Workstation Networks Group (Micro Group), directed by Shih-Pau Yen. With funding from Project Woksape, additional staff were added and a number of activities expanded to more effectively support the increased needs of the Project. In addition to Earl Schleske, Technical Coordinator for the Project, Kim Pearson and Dave Larsen provided technical programming assistance and consulting.

To encourage use of the IBM 4381 upgrade, St. Paul Computing Services worked closely with the Project office to customize the PROFS office-automation/electronic-mail system, develop reference materials, and provide terminal-emulation software to Woksape participants. The goals of this collaboration were availability of required mainframe computing services and increased reliance on electronic mail for communication among projects and with the Project office.

IBM provided two full-time people on-site to support the project: Al Becker and Bob Heggestuen. They assisted project participants, answering questions about IBM hardware and software, helping to insure that requested hardware and software will meet the particular project needs, ordering all hardware and software for the projects, providing a full-time interface between the University and IBM, and helping to locate needed technical assistance from within IBM Corporation.

Instructional Design

The development of quality instructional software requires that careful thought be given to the objectives of the Project, and that sound principles of instructional design be applied during the planning stages. Project Assist, funded half by Project Woksape and half by ACSS, provided support in this area, as well as in the assessment of available software and development tools. Project Assist was started under Stanley Trollip, formerly of the College of Education, and is now managed by Michael Johnston, Lecturer in Curriculum and Instruction, currently reporting to Shih-Pau Yen.

Setup, Installation, and Maintenance of Hardware

Project Woksape contracted with the Engineering Services Group of ACSS to provide initial setup, installation, and testing of all Woksape grant equipment, as well as on-site maintenance support for all Woksape-granted systems for the term of the grant.

Software Site Licenses

Project Woksape, in cooperation with ACSS and the Micro Group, has purchased a number of site licenses for software requested by a number of projects, with potential for significant positive impact on the project as a whole: PC/PILOT, an authoring language from the University of Washington; TRACER, a command-driven ray-tracing package that yields high-quality computer-graphics imagery; Texas Instruments' Personal Consultant Plus, a frame-based expert-system builder; Scheme, TI's dialect of LISP; IMSL mathematical subroutine library; SPSS/PC+, statistical software library; and STATA, a statistical-analysis program with sophisticated graphics routines. The TI site license was upgraded to include PC EASY, a simplified expert-system shell; PC ONLINE, for interfacing to real-time data acquisition and control systems; and PC IMAGES, a graphics library for Personal Consultant Plus. Also acquired was a multiple-copy discount for GoldWorks II, a tool for developing expert systems.

Project Activities

The first year of the project was spent organizing the Project office, determining project technical and financial support needs, addressing budgetary issues, and establishing the means for supporting individual projects. Development of high-quality instructional software is an intensive activity, requiring significant levels of faculty effort. This is an area for which it has been difficult in the past to obtain funding or adequate release time. Further, it is an activity for which faculty receive very little recognition in the traditional promotion and tenure process. Early on, it was felt that a key to the overall success of Project Woksape would be provision of the proper elements of support for faculty involved in the project. This support, therefore, encompassed a number of key elements: setup, installation, and maintenance of granted systems; adequate technical support for both hardware and software; assistance in instructional-design issues; faculty summer-salary support; adequate programming assistance; and funding for non-IBM hardware and software.

Over the course of the grant period, there have been significant developments in sophistication of IBM hardware, as well as in software for those machines. One result of this progress is that, early in the project, there was a conscious decision to furnish high-resolution Enhanced Graphics adaptors and monitors with all PCs provided by the Project, unless investigators indicated a need for the more-powerful Professional Graphics adaptor. The strategy was to provide researchers with effective tools for devising the most creative instructional software possible and to position each project for the assumed migration to higher-resolution graphics as a standard.

In the summer of 1988, IBM's new line of Personal System/2 computers became available. From that time on, all projects have received PS/2 machines, unless there was a specific need for a different machine. By furnishing researchers with sophisticated equipment and offering a full range of support services, IBM and Project Woksape showed confidence in the principal investigators and encouraging them to produce innovative software that tests the limits of the technology.

Since publication of the 1987 annual report, staff members of the Project office, Microcomputer and Workstation Networks Group, Engineering Services, and Project Assist have worked with faculty investigators to achieve noteworthy success in several endeavors.

1. Instructional Computing Fair

In May 1988, Project Woksape sponsored an instructional-computing fair at which over 60 Woksape projects were demonstrated. This event served as the final report to IBM executives, who came from headquarters in Connecticut to review progress at the University of Minnesota. The most significant benefit of holding the fair, however, was the synergy promoted by professors and students seeing the work of other departments and sharing ideas and experiences gained through their Woksape research. Response from IBM indicated this event was one of the most impressive computer fairs they had seen.

2. Project Assist

On July 1, 1988, responsibility for management of the instructional-design staff of Project Assist moved to Project Woksape. Over the last year, there have been several staff changes, renewed attempts to reach faculty members in a wider range of colleges than in the past, and plans to serve as a resource center for faculty members looking to use existing instructional software rather than develop their own. The result is that, as Project Woksape's office closes, Project Assist is merging with the Microcomputer and Workstation Networks Group. The name of the office has been changed to Faculty Resource Center, and it has moved to 113 Shepherd Labs.

3. IBM Academic Computing Conferences

The 1986 University AEP Conference was held in San Diego, California. Participants from the University of Minnesota were as follows:

- "Graphics and Analysis for Architectural Design" - Lee Anderson, School of Architecture and Landscape Architecture

- "Interactive Courseware Simulations for Fruit Farm Managers" - Albert H. Markhart III, Department of Horticultural Science and Landscape Architecture

- Donald R. Riley, Director of Project Woksape, chaired two sessions: Software Design Principles and Programming Beyond Turbo - PGA

Boston, Massachusetts was the site of the 1987 IBM ACIS University Conference. Three University of Minnesota projects were presented there:

- "Microcomputer Software for Heat Transfer Education" - Kanchan Kelkar, Department of Mechanical Engineering

- "Systems Development for an Experimental Markets Laboratory - Gordon L. Duke, Department of Accounting

- "Teaching the 'Integrated' Aspect of Integrated Manufacturing Systems" - Patrick J. Starr, Department of Mechanical Engineering

In the fall of 1987, IBM sponsored several regional conferences. The University of Minnesota was represented by 10 Woksape projects at the midwest-region's IBM Conference on Academic Computing at the University of Wisconsin-Madison in October, 1987.

In 1988, the national conference was held in Dallas, Texas. Three Woksape projects were represented in the talks and demonstrations:

- ''Graphics and Analysis for Architectural Design'' - Lee Anderson, School of Architecture and Landscape Architecture

- ''LIRE, LESEN, LEER: Developing Reading Comprehension in a Second Language'' - Dale Lange, Department of Curriculum and Instruction

- ''Comparison of Timber Harvest Scheduling Plans'' - Matthew H. Pelkki, Department of Forest Resources

- "Computers in Mechanical Engineering: Curricula in Evolution" - Donald R. Riley, Department of Mechanical Engineering

The 1989 conference, held June 22-24 in Anaheim, California, included participation by six Woksape researchers:

- ''4BARFUN: A Tool for Intuitive Design of Fourbar Linkages'' - Zine-Eddine Boutaghou, Department of Mechanical Engineering

- ''JAWS - A System for Modelling Human Jaw Motion in Three Dimensions'' - Margaret Hartfel, Department of Orthodontics

- ''Modeling of Semiconductor Devices on IBM PCs'' - Julio Costa, Department of Electrical Engineering

- ''Soil Taxonomy Software: Tedious Learning Made Easier" - Pierre Robert, Department of Soil Science

- ''Computer Aided Instruction for Hebrew'' - Tzvee Zahavy, Department of Classical and Near Eastern Studies

- Donald Riley, Director of Project Woksape, chaired the session on computer-assisted instruction in mechanical engineering.

In addition to the presenters listed above, the Project office sent key support people to this conference each year. In 1989, this included one person from Project Assist and two people from the Microcomputer and Workstation Networks Group.

4. Pilot Test Classrooms

At the beginning of Project Woksape, the Advisory Committee agreed to set aside funds for at least two facilities that Woksape researchers could use for pilot-testing their software. The College of Liberal Arts allocated space, Academic Computing Services and Systems (ACSS) provided funds to remodel the areas to accommodate computer labs, and Project Woksape furnished hardware and software. As a result, two new classroom/laboratory spaces opened up in Fall Quarter, 1988, in 121 Elliott Hall on the East Bank, and in 135A and 135B Classroom Office Building on the St. Paul campus. Each is equipped with 20 PS/2 Model 50 computers with VGA monitors, all connected via Token Ring, with a PS/2 Model 80/111 as a network server. The classrooms are administered by ACSS, along with the other microcomputer labs on campus. Priority for use of the IBM classrooms is, however, given to Woksape professors who are pilot-testing their instructional software.

At this time, pilot-testing instructional software in these labs is not common. We need to find ways to make the classrooms useful particularly as classrooms and to encourage professors to test their software in this comfortable, networked environment.

5. Technology Transfer Project

In 1988, the University of Minnesota, along with 17 other AEP schools, signed a contract with IBM, agreeing tosibmit to Wisc-Ware at least 10 programs that run under Microsoft Windows, in return for 40 PS/2 microcomputers. By the time the development software arrived from Microsoft, the contract deadline had moved from June 30, 1988 to December 31, 1988.

In all, 14 Woksape investigators participated, supervising the modification of their Woksape software to run under Microsoft Windows. In most cases, this meant significant revision of the user interface and the instructional approach, and rewriting the code in C. In return for their efforts, each project received a PS/2 Model 60 or Model 80, development software, and funds to hire a programmer. Dave Larsen, Kim Pearson, and Earl Schleske of the Micro Group offered training sessions on programming in C and in Windows, and continued to organize roundtable discussions and provide consulting support through the duration of the project.

Of the 18 participating schools, only two -- Minnesota and the University of Wisconsin-Madison -- met the December 31 deadline. Project Woksape submitted 17 Windows programs to Wisc-Ware, and IBM informed us that the University of Minnesota did an outstanding job of meeting the contract terms.

Project Evaluation

The first general review of the project was conducted on October 27, 1986, with a visit from John Daily, General Manager, IBM Academic Information Systems. An Annual Report summarizing the first year's activities under the grant was published in conjunction with that review. Fifty-seven projects were described in the 1986 Annual Report; in the report for 1987, that number had grown to 91 projects, with representation in 14 of the University's 18 colleges and professional schools. Final IBM review of Project Woksape was conducted in the spring of 1988, at the Instructional Computing Fair described above.

Final Project and Equipment Audit

As the Project office closes, we have made every effort to leave the University with accurate information about the equipment granted, as well as to assure that the equipment has been used for its intended purpose. As a result of an audit of individual projects that had not shown significant progress, several computers were reallocated to projects that had been successful and would benefit from expansion. In addition, some University support funding was reclaimed and allocated to such ongoing support functions as equipment maintenance, site licenses, and instructional-software design for the 1989-90 fiscal year. Ramona Fox in the Project office worked closely with Julie Mikeworth of Property Accounting to ensure that the equipment in the Project Woksape data base, which lists everything IBM delivered through the grant, is accurately assigned to individual departments.

Participant Survey

In an attempt to evaluate the overall impact of the IBM grant on instruction and personal computing at the University, we sent a "Survey on the Effects of the IBM Grant for Project Woksape" to over 200 grant participants. The survey appears at the end of this report as Appendix One. One hundred fourteen persons responded. Results of the survey cannot be regarded as either surprising or conclusive, but they can provide a start at quantitative evaluation of the use of computers in instruction.

Of those who responded, there were 45 Professors, 28 Associate Professors, 21 Assistant Professors, 8 Students, 8 Academic Professionals, 3 Civil Service employees, and 1 Instructor. The number of responses per college or school were as follows: Agriculture 13; Biological Sciences 8; Counseling Services 3; Dentistry 2; Education 10; General College 4; Graduate School 6; Institute of Technology 22; Law School 1; Liberal Arts 29; Medical School 3; Natural Resources 5; Nursing 4; Pharmacy 1; Management 2; St. Paul Computing Services 1; Veterinary Medicine 2.

Respondents were asked to rate, on a scale of 1 to 5 (negative to positive), the effect of the Woksape project on their promotion or tenure, research, teaching, and service activities. A response of 3 indicated no effect. The averages are shown in the table below:

Rank	**Ten.**	**Res.**	**Tchg.**	**Svc.**
Professor	3.41	4.27	4.32	3.30
Assoc. Professor	3.18	4.14	4.39	3.04
Asst. Professor	3.48	4.33	4.38	3.19
Total	**3.39**	**4.27**	**4.31**	**3.32**

Examining these averages across colleges, one interesting result is that professors in colleges whose homes are on the St. Paul campus tend to view their projects as of greater benefit in their professional evaluation than do professors on the East or West Bank campuses.

Of the total time these respondents' Woksape-granted computers are in use, about 50% is for research, 28% for teaching, 10% for service, and 12% for such other activities as correspondence and administrative tasks. Use of the computers is by students 50% of the time, faculty 38%, academic professionals 7.5%, Civil-Service staff 2.5%, and others 2% of the time.

Respondents indicated, on a scale of 1 (very unlikely) to 5 (very likely) whether or not, in the absence of Project Woksape funding, they would continue to develop instructional software, use instructional software, or upgrade the software they developed. The average of all responses showed a slight indication that development among faculty will continue without support funds (3.54). There is a strong likelihood that these faculty members will continue to use instructional software, whether their own or others' (4.64); and a good chance that they will continue to improve the software they have already developed (4.36).

We asked respondents to evaluate the support services engaged and at least partially funded by Project Woksape. The support functions listed are

1. Support from University staff in the Project Woksape office
2. Support from IBM staff in the Project Woksape office
3. Maintenance and setup by Engineering Services

4. Software support from the Microcomputer and Workstation Networks Group
5. Instructional-design consulting from Project Assist
6. Mainframe services, including electronic mail, from St. Paul Computing Services
7. Pilot-test facilities funded by Project Woksape, installed by Engineering Services, and staffed by Academic Computing Services and Systems.

None of these services cost the Woksape participants any money. We again used a scale of 1 (Inadequate) to 5 (Excellent). For each service, there was also a box marked N.A., to indicate no occasion to use that service. In the tabulation, this is considered a non-response. The results appear in the table below:

	No. of Responses	5 Excellent	4	3	2	1 Inadequate
Project Office	104	64	29	8	3	0
IBM Staff	78	35	24	12	5	2
Eng. Svcs.	92	40	32	15	3	2
Micro Group	80	22	29	15	10	4
Project Assist	54	18	12	14	7	3
SPCS	76	20	18	33	3	2
Pilot-Testing	37	5	11	16	2	3

Finally, we asked for responses to some more subjective questions. First, we wanted to know whether or not the Woksape-funded development had resulted in any spinoff projects or additional, verifiable benefits to the department. Sixty people said no, while 54 indicated there had been additional benefits beyond those provided by Project Woksape. In several cases, the impetus provided by the Woksape grant encouraged departments or colleges to fund computer labs for their faculty or students. Notable examples are the College of Natural Resources, the Departments of Political Science, Sociology, and History, and General College. The success of project FOR01 has resulted in an additional $143,000 in support from the state legislature, and another $140,000 for a two-year expansion of the project. One Assistant Professor in the Medical School credits the Woksape grant with receiving the Herz Faculty Teaching Development Award. Several respondents have received awards for their Woksape software, including Robert Leik of Sociology, who received the EDUCOM/NCRIPTAL software award in 1988. A Professor in General College says that the Woksape grant contributed to receipt of a $76,000 grant from the Annenberg/CPB Project; the Department of History will receive a million-dollar grant to do research on the 1880 U.S. census, due in part to the stunning success of Woksape-funded software developed there. Many other respondents mentioned such benefits as breakthroughs in research, publications, improved teaching, and better student comprehension of classroom material.

With one or two exceptions, everyone was extremely pleased with the results of the entire Project Woksape effort. When we asked what changes they would suggest in grant support or management, the two mentioned frequently are regular review of projects, to encourage earlier productivity; and more central support for programming resources, including names of programmers to hire and funds to hire them. Most respondents, even if they had suggestions, praised Project Woksape for leading their departments into the 20th century, for causing them to take a new look at their teaching techniques, and for giving them opportunities they believe they would never have had otherwise.

Results of the Project Woksape Grant

The effects of this substantial contribution by IBM to the computing environment of the University of Minnesota are far-reaching and probably broader in influence than anyone expected at the start of the grant period. Specific accomplishments of each project are included in this report. Throughout the University, the effects of Project Woksape are evident in the increased use of computers for instruction. An auxiliary effect is that many faculty members now include the new medium of computers in preparing class material. The consequences of this effect are just beginning to be realized.

From discussions with Woksape participants and College Computing Coordinators, it is clear that the IBM grant has achieved the goals set forth in the original proposal, and has had some unanticipated effects on teaching and research at the University as well. Results and accomplishments of the AEP grant can be classified in two ways: general, sometimes abstract effects on the educational environment of the University; and specific accomplishments of goals set forth by a college or a particular project proposal.

Results that enrich the educational and research environment by introducing personal workstations into teaching and research on the Twin Cities campus

- The grant has increased student access to microcomputers by enabling colleges or departments to set up computer labs. As a direct result of Woksape funding, student labs now exist in the Colleges of Agriculture, Natural Resources, and Education; Departments of Electrical Engineering, Mechanical Engineering, Psychology, and Rhetoric; and the School of Management. Academic Computing Services and Systems and Project Woksape jointly established two facilities for pilot testing instructional software, which are available as computer labs when pilot testing is not in progress.

- Proposals submitted to Project Woksape have increased in sophistication over the three-year grant period. This indicates that faculty members' knowledge of computing and instructional design has increased, and also that they are learning more about the application of personal computers in instruction. Because grant recipients are required to consider explicitly how to accomplish their instructional goals, improved educational techniques may be another side effect of the AEP programs.

- In several cases, principal investigators have indicated that, because of experience with their Woksape projects or because of the availability of Woksape-supplied computers, they have been in a better position to apply for major funding from such sources as the government.

- Faculty members who are not Woksape participants are often intrigued by what their colleagues accomplish using computers in the classroom, and are thus encouraged to try using computers themselves.

- The grant of computers and programming assistance from Project Woksape is often a catalyst for a department or college to become involved, making additional financial commitments to computing resources for students and faculty. Once departmental administration sees how effective the computers have been in education, commitment of precious funding becomes more reasonable.

- Because use of computers in education is widely believed to improve the educational climate, better prepare students for careers, and indicate that a university is in step with the latest developments, the IBM grant has the delayed effect of attracting good students and faculty to the University of Minnesota. Thus, it is in harmony with the current institutional planning process.

- The aspect of the project in which participants were encouraged to use electronic communication for local, interstate, and international communication has improved the research of Project Woksape participants, as they more easily exchange information with colleagues.

Specific successes of colleges and projects

- In the initial Project Woksape proposal, the College of Agriculture indicated plans to furnish a pilot-test facility. That facility now exists and is used by a number of faculty members on the St. Paul campus. It serves as a model for other departments who consider establishing computer labs.

- The School of Architecture and Landscape Architecture has produced one of the most successful efforts for Project Woksape by establishing an architectural design studio with 32 PC/ATs, two RT PCs, and three PS/2 computers, all of which are in heavy use by design students and teachers. Even students who have graduated and gone on to begin architecture careers return to use the design-studio facilities.

- In the College of Liberal Arts, several departments are collaborating on a series of language-teaching modules. The Departments of French and Italian, Spanish and Portuguese, German, and Russian and East European Languages are collaborating with the Department of Curriculum and Instruction on developing an adaptive system for customized language instruction. This effort, while improving the quality of language instruction, is designed to accommodate new, increased foreign-language requirements in the College of Liberal Arts.

- In the Department of Mechanical Engineering, in addition to developing software to be used in all four years of the undergraduate curriculum, a new computer-assisted sophomore-level course on computation has led to a major review of the curriculum, with a move toward significant reliance on computer-assisted instruction. A departmental microcomputer lab will provide students access to software developed under Project Woksape grants.

- In General College, the Woksape grants have provided some incentive for faculty to change direction in their teaching and research to meet Commitment to Focus recommendations.

- In the Medical School, Project Woksape grants encourage ''interdisciplinary development of educational technology in the biomedical sciences.''

- St. Paul Computing Services, in the initial proposal to IBM, set forth a goal of developing a ''seamless'' IBM computing environment for University users. With the upgrade of the 4381 mainframe, development and support of YTERM terminal-emulation software, customizing PROFS, BITNET support, and establishment of a link into the UMNnet Ethernet, that goal has been achieved. Faculty members who would otherwise never have used the IBM mainframe now use it regularly for electronic communication.

- Several software packages developed with Project Woksape funding are now available commercially. For example, one program from Mechanical Engineering has been licensed to approximately 30 companies and 30 universities.

Conclusions, Recommendations, and Future Directions

Success is a difficult thing to measure, especially in the area of impact on learning processes. When we embarked upon Project Woksape, we did so with the conviction that the results would be improvement in the learning environment for students, improvement in the teaching and research environment for faculty, and an overall beneficial impact upon the entire University. We are convinced that this is true and the Project has had major positive impact on the campus. This is nearly impossible to quantify, however. We have tried in this document to describe the goals of Project Woksape, detail our approach to accomplishing those goals, and summarize the results. What we describe is a snapshot in time. The true impact of the Project will not be known for several years as we now begin to use the resulting software in many curricula. We are confident, however, that the results will justify the investments of IBM Corporation and the University. While we are very proud of the results of the Project, however, we think it is important to analyze the weaknesses, both for our own internal benefit and for the benefit of others who are involved in, or are considering, developing instructional software.

The major weaknesses in the execution of Project Woksape were in early organization and support. It is clear that the University did not fully understand the magnitude of the effort involved in developing quality educational software. (It is also likely that IBM did not fully realize the magnitude of the undertaking.) Lack of adequate project administrative personnel, space, and support budget were major hindrances throughout the first year of the project. The budget issue was resolved about seven months into the project, with the allocation of $800,000 by the University; valuable time had been lost, however, and many projects got off to a poor start because of inadequate budgetary support. In each of the next two years, the University provided $1,000,000 and, in the final year, $600,000. This funding was used for central support services (administrative, technical, instructional design, on-site maintenance), non-IBM items of hardware and software, programming assistance (mostly graduate students), and supplies. While the funding was substantial, it was not sufficient to cover all needs. Most significantly, it was not adequate to pay for faculty time, either release time during the year or summer support.

About halfway through the project, it became apparent it was impossible to administer the program with just a 50%-time Director. A project administrator was added near the end of the second year. Earlier recognition of this need would have had beneficial impact on the Project by improving communication and enabling earlier identification of projects with problems, to allow corrective action to positively affect their results.

One continuing problem has been the difficulty in tracking delivery of hardware and software. With over 600 workstations of various configurations with various optional hardware and software items, it is difficult to track what has arrived and what each project has received. In our case, this was compounded by two different methods for tracking and two different data bases being maintained: one in the Project office and one by Engineering Services staff, who delivered and installed each system. This problem might have been anticipated and alleviated by assistance from IBM early in the project.

In spite of early organizational problems, Project Woksape benefitted very early from a strong Microcomputer Services Group, which was already in place and provided the needed centralized technical support. Project Assist was formed to complement the Micro Group's technical expertise with assistance for faculty in instructional design and planning for their projects.

During the course of the Project, we encountered a number of IBM-related technical and other problems. One significant problem was the lack of standards for programming-language and graphics support. A rapidly-changing product line contributed to this problem when, for example, the Professional Graphics Controller and Display were discontinued and no longer supported by enhancements to the Graphics Development Toolkit. A major problem for some projects in terms of central support of utility and graphics libraries was incompatibilities between the IBM-supplied language compilers. The principal languages used by various projects included C, Pascal, FORTRAN, Basic, and Lisp. Some of the large projects actually used three or four different languages. The inability to compile and call routines from different languages eventually led some projects to abandon the IBM compilers for Microsoft compilers.

There are several important lessons learned from Project Woksape that are worth passing on to anyone contemplating a similar undertaking or planning to support development of instructional software. First, it is a major undertaking to develop effective, quality software of any kind, but it is especially difficult to develop instructional software. Effective instructional software requires innovative thinking and good planning if it is to be used for more than just electronic page turning. The responsiveness and intimacy of the personal computer, coupled with more sophisticated graphics, provides, for the first time, the right environment to personalize instruction in a way that can ''immerse'' students in the learning experience. This immersion should be the goal of any instructional-software development. In addition to the requirements for appropriate technology for courseware delivery, this requires significant planning and design, along with adequate technical support. We believe that this is best and most effectively provided by a strong central support organization.

The computer is no longer a novelty, but rather a significant tool for all disciplines, for all areas of academic life: teaching, research, service, and administration. Recognition of this is an important ''cultural'' shift within the university that must take place if effective application of computing is to occur. Instructional computing and instructional-software development should be viewed as essential activities within the academic environment. The effective delivery of computer-aided instruction must be in harmony with integrated use of the computer in all these other areas of academic life.

Second, development of *quality* instructional software is a time-intensive activity, with a time commitment far beyond that for normal teaching activities. Its requirements for innovation and effort equal those for research. We believe that faculty, as subject-matter experts, are key to development of quality instructional software. Faculty development of instructional software can, however, have a negative impact on their research efforts, since such activities do not generally receive appropriate recognition in terms of promotion and tenure considerations. This must be changed. It is time to develop appropriate peer-review mechanisms for instructional software. Several national organizations are beginning to address this area: EDUCOM, the American Society for Engineering Education, and others. It is critical to begin appropriate planning and discussion on each campus as well.

Third, a successful development activity will begin planning early for *implementation* of the resulting software. Planning for adequate resources and modes of delivery (computer classrooms, computer labs, dormitories, etc.) must begin early if the fruits of the development are to be realized. This includes planning for *distributed* support and assistance for students.

Project Woksape has been a great catalyst on the University of Minnesota campus. It has focused attention on an important technology with the potential for improving the learning process. It has caused a realization of the universal applicability of this technology throughout all the disciplines, and of the pervasiveness of its role in academic life. Through this intensive effort, we have identified our weaknesses and strengths. We hope to continue to capitalize on our strengths and to strengthen our areas of weakness, as an integral component of the University's internal planning process. We are thankful to IBM Corporation for having provided the enabling hardware and software that have given us such a boost in this direction. We are very concerned about sustaining the impetus provided by Project Woksape and seeing full realization of the fruits of this labor.

While current University planning is not complete, support of computing is expected to move from totally centralized support to centrally managed and coordinated, but distributed, support. This is in keeping with the trend to "network computing", in which the workstation is the delivery vehicle, with networks providing access to specialized central resources, such as electronic communication. Emphasis will be placed on providing workstation classrooms and labs, in which students will benefit from instructional software developed under Project Woksape, as well as software available from many other sources.

Support Services

Microcomputer and Workstation Networks Group

Shih-Pau Yen, Director

The Microcomputer and Workstation Networkss Group provided several levels of technical support to Project Woksape participants.

Technical Notes

Micro Group staff researched and prepared Technical Notes for distribution to Woksape participants. Technical Notes were distributed free-of-charge through the Micro Help-Line in 125 Shepherd Labs. Technical Notes typically included sample programs with documentation to illustrate possible applications of these features.

In past releases of Technical Notes, the Micro Group has provided software and documentation for many applications, including: programming graphics in Pascal and FORTRAN using the Professional Graphics, Enhanced Graphics, and Color Graphics adapters; developing and using software employing peripheral mouse devices; accessing the token ring network using NET/BIOS; linking the InfoWindows display with video disk technology; and using PIL (the Pascal Instructional Library) for authoring interactive programs, including CAI (Computer Assisted Instruction) courseware.

Woksape Roundtable Discussions

Micro Group members hosted periodic Roundtable sessions, during which Micro Group staff present short talks on special topics of general interest to Woksape participants, followed by a discussion time that allows participants to share information concerning their projects.

Topics for Roundtables have included: CAI courseware development and graphics programming, including VDI, GKS, implications ofnew IBM graphics display adapters (VGA and MCGA), the OS/2 operating system, and programming with Microsoft Windows.

Microcomputer Newsletter

Micro Group staff, through their Microcomputer Newsletter, provided several articles of interest to Project Woksape participants. Articles have included general Project Woksape announcements, numerous hardware and software reviews, and software site license information. These articles have offered previews of the OS/2 operating system, DOS 4.0, and hew compilers.

Miscellaneous Consulting Support

Project Woksape participants, as University microcomputer users, have access to consulting services provided on a daily basis by the Microcomputer and Workstation Systems Group. This involves free consultation concerning hardware and software questions on a phone-in or walk-in basis at the Help-Line located in the Microcomputer and Workstation Research Laboratory in 125 Shepherd Labs. Help-Line hours were expanded in order to improve access for Woksape participants. Participants also had access to many low-cost short courses taught by Micro Group staff throughout each year. These short courses covered such topics as Lotus 1-2-3, WordPerfect, dBASE, the PC-DOS operating system, and organizing and maintaining a hard disk.

Personnel Support

The Micro Group has been a source of trained personnel for Project Woksape. Earl Schleske, co-manager of the Micro Group, was employed half-time with the project as Technical Coordinator. Kim Pearson provided special software technical support as a full-time Analyst Programmer; Dave Larsen provided part-time technical support as a Senior Applications Programmer; and Kathy Olson, Jr. Applications Programmer, worked part-time in support of Woksape database management.

St. Paul Computing Services

Melvin L. Sauve, Director

Background

St. Paul Computing Services (SPCS) has been involved in Project Woksape since its very beginning. SPCS remains the sole open-shop computing facility within the University that operates an IBM mainframe (IBM 4381). Because of SPCS familiarity with IBM hardware and software, its staff was involved in getting Project Woksape underway. SPCS was charged with the task of reviewing all of the initial proposals and recommending hardware and software required to accomplish the objectives defined. SPCS worked closely with the Office of the Vice President for Academic Affairs and the participating college deans in finalizing configurations so that initial orders for equipment and software could be placed.

BITNET (Because It's Time NETwork) Project

During the summer of 1985, Project Woksape provided SPCS with two 9600 bpi IBM 3865 modems (one was installed in Madison, Wisconsin) to connect to the BITNET network. Since that time, BITNET has become a popular means of communicating within the University of Minnesota and with other participating institutions. BITNET has also served as a link locally among principal investigators of Project Woksape, and nationally between Woksape participants and colleagues at other universities. The popularity of BITNET locally has resulted in the expansion of numerous nodes within the University of Minnesota that are served through SPCS:

Node	Computing Facility Name	Mainframe
UMNACBR	Academic Computing Services and Systems	CDC
UMNACCA	Academic Computing Services and Systems	CDC
SIMVAX	University Simulation Facility	VAX
UMNACVX	Academic Computing Services and Systems	VAX
UMNADMIN	Administrative Information Services	IBM
UMNDUL	University of Minnesota Duluth	VAX
UMNHSNOS	Health Sciences Computing Services	CDC
UMNHSNVE	Health Sciences Computing Services	CDC
UMNMOR	University of Minnesota Morris	VAX
UMNSOM	School of Management	IBM

SPCS is the hub (central connection site) for the University of Minnesota. The School of Management, Health Sciences, and the ACSS mini-VAX are connected to SPCS.

VLSI (Very Large Scale Integration) Project

The acquisition of VLSI software (integrated circuit design facility) and a Woksape proposal (Project No. IT22) initiated by Gerald Sobelman, Electrical Engineering, during the summer of 1986, resulted in an upgrade of SPCS's 4381 system from a P12 to an R14 model in December 1986 and installation of an additional IBM 3380-DB4 Disk Storage unit. In

November 1986, SPCS installed the VLSI software and coordinated the education of the Electrical Engineering professors who would be using VLSI for classroom instruction. Student use of the VLSI system began in January 1987, through a local area network established on the remote Minneapolis campus. The use of VLSI has increased in each succeeding academic quarter.

PROFS (Professional Office System) Electronic Mail Project

One of the unique features of Project Woksape is the initial guidance and follow-up support of grant recipients in the use of electronic communication (mail and bulletin boards). Increased dial-up access was necessary to accommodate the Woksape users, so Project Woksape provided a second 7171 Protocol Converter. Increased numbers of users leads to increased demand for minidisk space, so SPCS also obtained through Project Woksape, an IBM 3380 disk drive.

The original SPCS electronic-communication software (a previous release of PROFS, native operating system commands, and a public-domain Mailer package) did not include many of the advanced features desirable for the group's communication. Again, with Woksape support, SPCS acquired, installed, and further developed PASF (PROFS Application Support Feature), which required ISPF (Interactive System Productivity Facility). The main-menu electronic-communication system became known as the Satisfy project, and was completed in late summer, 1987, with the release of the PROJECT-GROUP utility. PROJECT-GROUP delivers the ability to define private groups of users; each group then employs menu screens that have been tailored for it. From the tailored menus, users may read, send, and review mail; view or contribute to bulletin boards; use and update electronic-mail directories; and run various utilities (file transfer, mainframe file management, etc.). Project Woksape maintained the group's bulletin board and directory and encouraged participants to use them.

PROFS provides many utility features, but at a price in system resources. Indeed, the increased number of users over the past years requires careful monitoring of system performance. The VMMAP program was acquired to record and analyze use of system resources. Along with a system upgrade from a model P12 to an R14, the High Performance Option (HPO) was acquired to take full advantage of available memory.

Electronic communication is rapidly increasing in popularity, but the printed word is still used, to a great extent. SPCS acquired an IBM 3820 laser printer in 1986 and, through Project Woksape, purchased extended support software for printing (OGL, PMF, and APL).

Additional Project Woksape Support

Networking has been a major emphasis for the University, and TCP/IP was the protocol agreed upon by the All-University Committee for Network and Communications Planning. TCP/IP was acquired under different auspices, but ancillary support came through Project Woksape. This support is in the form of programming languages (C and VS Pascal) necessary for maintaining the TCP/IP software; these products were installed and released to our general users, thus broadening the SPCS program offering.

Project Woksape provided leading-edge database software in AS (IBM's Application System) and SQL/DS (Structured Query Language/Database Software). The addition of these two products has made SPCS a more comprehensive information center.

Two IBM PC/ATs from Woksape have enabled SPCS to support Woksape participants and other users in communication, using the PC SAS product, which SPCS distributes and supports.

SPCS Support Services

SPCS collaborated with Project Woksape staff in preparing the Woksape Electronic Communications Manual. This document describes how project members connect to the IBM mainframe and how to use the main menu system for electronic mail, bulletin boards, and file management. SPCS holds a site license for YTERM, and IBM PC communications package. SPCS staff developed an easy setup procedure for YTERM, and the Project office distributed copies of YTERM to all interested participants.

SPCS provided Woksape participants with Help-Desk service (walk-in and phone line) in all areas of mainframe processing. Questions ranged from how to send electronic mail to colleagues at foreign institutions, to how to run particular programs. Participants with difficult communications problems received on-site visits.

College of Agriculture

Impact of Project Woksape on the College of Agriculture

Mark S. DeBower, Computing Coordinator

Grants from Project Woksape have greatly accelerated the propagation of microcomputer-based teaching tools in the College of Agriculture. While supporting many individual projects within departments, Woksape also supports a college-wide facility for testing and refining instructional software packages before they are fully incorporated into teaching. The result is a more computer-literate college for both faculty and students.

The results of our grants have been astonishing, with faculty taking many innovative avenues for the success of their projects. Since the earlier phases of the Woksape grants, we have seen the evolution of higher levels of thought, greater sophistication, and the use of new technologies in developing instructional computing projects. Initially, faculty were mainly interested in developing such lower-level computer applications as tutorials, integrating commercially available software packages into existing courses, and using the computer as a dynamic blackboard.

As time progressed, we saw the development of totally new Woksape proposals built around new courseware that includes computerized image capture, simulation models, and interactive communication. We are also starting to see proposed projects that are built around such new technologies as interactive video and CD ROM applications.

Woksape has been an education within itself, exposing faculty to new ways of thinking about instruction because of access to microcomputers for project development and testing. It has allowed them to explore the use of technology as a tool to enhance the educational process.

Through the use of our pilot test facility, even faculty without official Woksape grants have been able to implement their instructional ideas and research involving microcomputers. Because of Woksape funding, students have been exposed to new tools that aid them in learning and accessing information. As a result, students taking these new-found computer skills into the job market will find better employment opportunities.

Project Number: AG01

IBM Computers for Innovative Teaching in Horticulture and Landscape Architecture

Emily Hoover, Albert Markhart, and Joan Nassauer

Department of Horticultural Science and Landscape Architecture

Purpose

This project is composed of 3 subprojects. Professor Joan Nassauer is developing LANDUSE software used in a lab network configuration as part of Landscape Architecture 5073, Regional Landscape Analysis. Dr. Albert H. Markhart, III is developing simulation software of basic plant-water relations and mineral-nutrition concepts to be used with Plant Physiology 5183, Water, Minerals and Translocation. Dr. Emily Hoover and Dr. Albert H. Markhart, III are developing an interactive simulation of managing a strawberry farm for use in Hort 5033, Small Fruit Production.

Progress

LANDUSE was successfully adapted for use on a network and was an integral part of Regional Landscape Analysis during the Spring of 1987.

Several modules of the water relations software have been completed and used as part of Water, Minerals and Translocation during the winter of 1986. These have recently been adapted to Quick Basic and run much faster in compiled mode. Quick Basic is also being used to develop the remaining modules.

A beta version of the Strawberry Farm Simulation has been evaluated by several fruit scientists. Their comments and suggestions are being incorporated into the first version for general release.

Future Plans

LANDUSE will be expanded as part of a multidisciplinary instructional program in Geographic Information Systems that will bring together instructors from Soil Science, Landscape Architecture, and Geography.

An expanded version of the water-relations exercises and simulations will be completed this fall and used in Water Minerals and Translocation during winter quarter 1988. Following this extensive testing of the software, copies will be sent to plant physiologists around the country for evaluation and feedback.

The Strawberry Farm Simulation will be completed this fall and used in Fruit Science during the fall of 1987. Additional feedback from students and from selected strawberry growers will be used for final revision before the software is offered for general use.

Equipment

1 PC/AT with Enhanced Graphics display
2 PCs with Enhanced Graphics displays
3 Enhanced Graphics displays
1 PS/2 Model 60 with VGA display
3 Proprinters
2 Colorjet printers

Project Number: AG 02

Integrating Workstations into the Classroom

Ann H. Duin, Laurie S. Hayes, Victoria M. Mikelonis
Department of Rhetoric, Technical Communication Program

Purpose

This project has three objectives: 1) to provide a set of inventional heuristics to assist technical communication students with researching, goal setting, and planning in their writing and speaking courses; 2) to design an integrated instructional system to assist technical communicators and programmers in designing screens, flowcharting programs, conducting task analyses, scheduling and tracking projects, and electronically composing pages (copy coding, typesetting, and printing); and 3) to develop a glossary of rhetorical terms and a graphics glossary with indexing features and integrated graphics for use in basic and advanced writing and speaking courses.

Progress

Objective 1. Professors Duin and Hayes are working on projects concerning objective one. Ann Duin has developed software to aid students in designing, developing, and documenting a feasibility study and has integrated this software into Rhet 3562, ''Writing in Your Profession.'' She used an authoring system known as ACCESS (A Computer Composing Educational Software System), developed by Donald Ross and Sheldon Fossum (Program in Composition and Communication) at this university, to design the software for this project. Her educational goals for developing such a set of inventional heuristics were to: (1) provide a model for students to see how analyses of audiences, purposes, and intended effects affects the first draft of a document; (2) build an environment in which students can explore the content and structure of proposals, progress reports, and final reports; (3) illustrate arguments that can be used to explain and evaluate components of these documents; (4) provide students with model cases of such documents; and (5) develop in students the ability to see how process leads to product or how nonacademic writing tasks can be broken down into key analyses and development of parts that lead to the whole.

Concerning experimental questions, she has investigated: (1) the act of designing CAI to encourage higher-level thinking and a knowledge of the process behind designing and documenting a feasibility study; (2) the effects of CAI on the first draft of a document vs. the use of computers mainly as a revision and editing tool; (3) the effects of good vs. poorly constructed CAI on students' writing, their outward behavior when using CAI, and their attitudes toward CAI; and (4) the effects of a 10-week or a 5-week computer environment vs. the traditional classroom on students' attitudes toward the writing course as a whole, their peer conference groups, their collaborative work, and computers.

Four sections of the course, ''Writing in your Profession,'' met for either 5 or 10 weeks in the College of Agriculture Woksape computer lab and also used the Rhetoric Woksape computer lab. Students used the software to aid in their use of the CAI and document development.

From an experiment in which equal groups of students were given different versions of the program, we found that students receiving the good version were more flexible when using it, were more involved and excited about their work, and produced writing of significantly higher quality than those students receiving the poor version.

Finally, results from an extensive questionnaire show that the computer technology did not impede instruction. The majority of students who spent 10 weeks in the computer lab had significantly more positive responses toward composing on computers and using the CAI than those students who had spent 5 weeks in the computer environment.

It appears that there are writing problems that are best solved by existing computer technology. Students can readily collaborate on documents, instructors can literally enter at each stage of the writing process to coach students, and instructors and students can see what others have done at each stage of the writing process rather than sharing only final typewritten documents.

Professor Duin reported on this project at the Spring IBM ACIS conference in Boston. Laurie Hayes has attended Project Assist workshops on computer-based instruction and national meetings for speech-communication professionals (Chicago) and technical-communication professionals (Denver) who are interested in the issues and problems of computer-assisted instruction in communication. She continues to review software and to investigate the relationship between microcomputers and the teaching of speech.

Objective #2. Professor Mikelonis is working on projects concerning objective two. She has fully integrated instructional systems to assist technical communicators as described under objective two. She has continued to incorporate workstations into three courses: Rhet 5561 ''Electronic Publishing,'' Rhet 5571 ''Newsletter,'' and Rhet 5581 ''Document Design.''

In the ''Electronic Publishing'' course, students were taught to code copy for electronic typesetting and page composition. Student manuals for coding page composition, developed as part of the previous year, were redesigned and piloted in the class. In the ''Document Design'' class, students' assignments included designing and writing both tutorials and end-user guides for computer software. Example projects in this course included the following: User's Guide to Communicating with BitNet Using *ProComm*, Tutorial for Using *Nota Bene*, Getting Started on the IBM Personal Computer AT, and others. The students' initial drafts were pilot tested the end of Spring quarter. For the ''Newsletter'' class, tutorials using WordPerfect to do online page composition, which were developed the previous year, were piloted Fall quarter.

Objective #3. This objective is currently not being met. The original professors in charge of this objective have withdrawn from the project.

Future Plans

In the 1987-1988 academic year Ann Duin plans to refine and further integrate and research the software developed for the ''Writing in Your Profession'' course. She will draw on theories of processing expository text and theories of conceptual, visual, and linguistic design as she studies the effects of instructional heuristics on students' cognitive processes. Laurie

Hayes plans to test and refine her theories on the relationship between microcomputers and the teaching of speech.

Equipment

2 PC/ATs with Enhanced Graphics displays
4 PCs with Enhanced Graphics displays
4 Proprinters
1 Streaming Tape Drive

Project Number: AG03

Design Applications in Agricultural Engineering and Engineering Applications for Non-Engineers

Mrinal Bhattacharya, Jonathan Chaplin, Kevin A. Janni, Curtis L. Larson, R. Vance R. Morey, John L. Nieber, Deborah J. Hansen
Department of Agricultural Engineering

Purpose

The emphasis of the project is to develop software to enhance instruction in Agricultural Engineering using graphics to facilitate input of information and to enhance results.

Progress

A graphics library for IBM PGC and EGA/VGA systems was implemented in Turbo Pascal for use by the student programmers on the project. The library consists of a number of routines for drawing circles, lines, polygons, arcs, and other graphic entities. It also contains functions to draw simple axes and arrows. The library ensures that graphics programming will remain consistent, despite the many students who will work on various projects. It also relieves students from worrying about graphics programming details and allows programmers to quickly begin producing graphics output.

A number of program modules were developed, tested in classroom situations, and refined, based on student input.

Modules:

HEATLOSS - Calculates heat loss from various components of an agricultural building.

VENTILATION - Calculates ventilation rates needed for agricultural confinement buildings to maintain desired conditions.

HEATER - Demonstrates the response of a water heater to different types of control.

PLOTPAK - An X-Y plotting program that takes data from ASCII text files and plots it on the screen or on a six-pen plotter.

TRACTOR - Simulates the effect of implement load and tractor specifications on tractor performance.

NUMBER - An instructional program that can be used to learn and practice number conversions between any two of the following number systems: decimal, binary, and hexadecimal.

STRIP SOURCES - Models time-dependent infiltration from a strip source, as in trickle irrigation.

LINE SOURCES - Models steady-state infiltration from a line source such as trickle irrigation.

AERATION - Allows evaluation of duct size, number, and spacing in a flat grain storage.

EVAPORATOR - Finds the various parameters of triple-effect evaporators to demonstrate the differences between feed configurations (forward, backward, and parallel feed) and the relationships between inlet feed temperature and steam economy.

VECTOR - A tool to facilitate teaching and learning of vector operations and other related subjects, such as the dynamic analysis of a tractor implement system.

SOIL LOSS - A data base to assist the student in calculating the average annual soil loss in t/ha.

FEMPAC (Finite Element Method Package of Learner Programs) - A series of programs designed for use in learning the finite element method has been modified to run on IBM PC's. The graphical output portion of the program has been modified for use with Golden Graphics Software to produce plots of the finite element grid subregions, the complete finite element grid showing elements and node numbers, and contour plots of the calculated values.

AIRFLOW - A finite-element program that analyzes the flow of air through grain when nonlinear airlow exists. The program utilizes the finite-element method to predict two-dimensional pressure patterns in the grain bulk. The program will work for any two-dimensional geometry.

VENTILATION CONTROL - Aids in selection of livestock ventilation equipment and allows evaluation of thermostat settings.

Equipment

3 PC/ATs with Professional Graphics displays
2 PC/XTs with Professional Graphics displays
1 PS/2 Model 80 with 8514 display
4 Proprinters
1 Color plotter

Project Number: AG04

A Microcomputer-Based System for Farm Management Instruction

Jeffrey Apland and Robert P. King
Department of Agricultural and Applied Economics

Purpose

The project has three major objectives: to design, develop and test interactive instructional modules for teaching production economics; to design, develop and test a prototypical farm-level commodity marketing decision support system (DSS) that can be used to teach concepts related to both the design and use of DSS; and to evaluate the effectiveness of these microcomputer-based instructional tools and identify priority areas for future development of instructional materials.

Progress

Efforts during the past year have been concentrated on the first two objectives. The software being developed is now reaching the stage where it can be used in classes, but it has not yet been formally evaluated.

Progress on Objective 1: Development of the instructional modules for production economics (IMPE) has proceeded along two tracks. Prototype modules that were earlier developed as Lotus worksheets were developed further into working versions for student use. Working versions of the four completed modules focus on various technical and economic characteristics of mathematical models of the firm. The modules include:

IMPE-1: Production Functions -- Functional Forms. This module allows the student to examine the technical properties of production functions with various functional forms. The user selects the functional form and sets the parameter values for one or two production functions. If two functions are used, comparisons of functional forms or parameter sets are facilitated. The user may select a graphical display with any combination of total, marginal and average physical product functions.

IMPE-2: Production Functions and Cost Functions. All of the capabilities of IMPE-1 are available in this module for a single production function. With additional price and fixed-cost information, this module generates cost functions for each production function and parameter set. In addition to the physical product relationships, total, average and marginal cost and revenue functions may be displayed graphically.

IMPE-3: Estimating Production Functions -- Curve Fitting. A variety of input/output "observations" may be accessed with IMPE-3 to fit algebraic production functions. The user may select data sets that reflect a deterministic output response for which an exact fit is possible. Alternatively, observations containing stochastic elements may be selected requiring the user to seek an acceptable representation of the output response. Graphical display includes observations, the estimated function, and errors of the estimate.

IMPE-4: Production Functions -- Factor-Factor Relationships. Similar in purpose to IMPE-1, IMPE-4 allows for the study of algebraic production functions with two variable inputs. Graphical displays include response functions for one input given selected levels of the second, and alternative input combinations for producing a given level of output.

These four modules will be used by students during fall quarter 1987 and refined before "stand-alone" PASCAL versions are coded. Designs are proceeding for similar applications to mathematical programming subject matter.

Progress on Objective 2: Coding of MMS, the prototypical DSS for commodity marketing, was begun during the summer of 1986. MMS is being programmed in Turbo PASCAL, making extensive use of the Turbo Access Toolbox and, in the future, the Turbo Graphix Toolbox. To date, efforts have focused on the price records subsystem -- a set of procedures for recording, editing, querying, and displaying data about commodity prices. This subsystem is currently being tested and will be used in Agricultural Economics 3300 during the fall quarter. Data structures and initial screen designs are also complete for the market transaction records subsystem, but coding has not yet begun. Forecasting and planning modules are also in the design phase.

In addition to MMS, several smaller programs have been developed to help illustrate concepts and tools related to management information systems in agricultural firms. These include: (1) a production-inventory simulation model that illustrates the effect of increased frequency of inventory reporting on the effectiveness of inventory management, (2) a field-record data system that is used to teach database design and to illustrate the use of a database management system, and (3) spreadsheets for annual cash-flow planning and capital budgeting.

Future Plans

To date, student use of software from this project has included a variety of spinoff applications and components of the applications described above. As a result of technical design and coding activities during the past year, full scale classroom tests of the production economics and decision support system software will be feasible during the 1987-1988 academic year. Also, other faculty who have used software developed under this project will be consulted regarding further refinements of the programs.

Equipment

3 PC/ATs with Enhanced Graphics displays
7 PCs with Enhanced Graphics displays
4 Proprinters

Project Number: AG05

Instructional Computing Laboratory

W. Keith Wharton and Mark DeBower
College of Agriculture

Purpose

The classroom developed for this project serves as the environment for the testing and evaluation of new instructional modules developed by College of Agriculture faculty. Instructional modules that promote the development of higher-level cognitive skills are given primary consideration for the use of this instructional-computing laboratory.

Project objectives include the following:

1. Provide a location for faculty to design, explore, test, and evaluate new teaching methods using the microcomputer. These methods should incorporate creative problem-solving skills, along with collaboration skills.

2. Evaluate the effectiveness of microcomputer-based instructional tools. Finished instructional modules can serve as models for other courses within the college and in related disciplines. The prototypes resulting from this project could enable significant gains in the use of computers as instructional tools.

Progress

The Woksape Instructional Classroom was designed to explore new ways of using the microcomputer more effectively in instruction. It is important to understand that before the classroom can be utilized a project must exist. Part of the process involves the recruitment of faculty willing to take the time to develop relevant CAI projects. Grants such as those offered through Woksape help, but we still find that the number of faculty willing to commit to the exploration of ideas is limited. Once projects do exist, the development of a knowledge base begins. Only at the point when students start to use the CAI applications can we begin to realize what is successful.

Over the past year, this dynamic laboratory has been used by several classes in the pursuit of new CAI methods. We are starting to see existing Woksape projects, including AG01 and AG02, enter the classroom for evaluation and testing. (See appropriate sections in this report for review of these projects). Woksape Classroom projects are taking on many dimensions. The following characteristics are starting to emerge.

1. *Time use of classroom:* Instead of scheduling just the CAI components of instruction in the classroom when they occur, instructors tend to schedule all class meetings for the entire quarter in this facility. This allows them the flexibility of using the computer equipment at anytime. What we are seeing is some instructors integrating the computer into the entire quarter's work.

2. *Use of projection equipment:* It has become apparent that computer projection equipment is a necessity in the microcomputer

laboratory. Instructors need this equipment to show illustrations of software applications, and also use the equipment as a dynamic blackboard.

3. *Students:* We have found that students entering the classroom come into it with varied computer literacy. It is a challenge for all instructors to get everyone up to the same level of competence before executing an application.

4. *Instructors in the classroom:* The Woksape Classroom is set up to accommodate 32 students working in pairs at 16 microcomputer workstations. One instructor in the classroom is not adaquate to assist all students. We have found that the most effective instructor/student ratio is 1:10. In situations where we have the maximum number of students, we suggest that two teaching assistants be available to help.

   We have also found that, before an instructor uses the classroom, he or she must demonstrate a superb working knowledge of the software being evaluated and tested. If the instructor does not totally understand the software, students with questions become frustrated at the lack of available help.

5. *Use of commercial software vs. "in-house" developed software:* Instead of spending time developing CAI applications from scratch, many instructors develop instructional modules around existing commercial software. This allows instructors the ability to evaluate and test the content of an application and not worry about problems with the actual application. We find that the main commercial applications being used in agriculture within the classroom are spreadsheet and database applications.

6. *Use of Local Area Network in the classroom:* Although we have been very successful in building an instructional module around the network (AG01: Regional Landuse software), most classroom applications cannot make use of it. The problems lie in the fact that most existing software packages (commercial or educational) do not make provisions for networking or the use of network printers. We have also found out that network function and commands are complex and frustrate both instructors and students.

Future Plans

The College of Agriculture has invested in the development of a telecommunications software package in conjunction with St. Paul Computing Services. It is our goal to facilitate the exchange of electronic mail and sharing of information among our students, staff and faculty. The classroom has been outfitted with telecommunication capabilities that include an SDLC asynchronous adapter.

In the future we hope to integrate computer telecommunication components into classroom activities. We will also use the Woksape Classroom as a testing and teaching facility for learning more about telecommunications and instruction.

Equipment

2 PC/ATs with Enhanced Graphics displays
16 PCs with 17 Enhanced Graphics displays
1 PS/2 Model 60 with VGA display
1 PC Portable
4 Proprinters
1 3812 Pageprinter

Project Number: AG06

An Innovative IBM System for Bringing Minnesota's Soils and Climate Data Bases into an Instructional Graphics Network

Mark Seeley and Pierre Robert
Department of Soil Science

Purpose

The department has teaching, research, and extension programs in the following areas: soil chemistry/fertility, soil genesis/classification, soil microbiology, soil physics and soil management, and climatology/agrometeorology. The department also has the responsibility of maintaining, upgrading, and utilizing two important natural resource data bases: county soil surveys (all 87 counties) and statewide climate/weather data (up to 165 years in length at some locations). These two data bases are used throughout the University (beyond just the departments in the College of Agriculture) and around the state. Software has been developed to manage, access, and utilize these data bases for instruction, research, and public-service functions.

The major purpose of this project is to create an innovative Token Ring Network System for managing these data bases and their associated applications software. The Token Ring environment in conjunction with high-resolution graphics makes all forms of these data (digital, graphical, and images) available to students, faculty, staff, and others. Servers on the Token Ring provide residence for the data bases and applications software, and are managed by faculty members. Workstations (primarily PC/XTs) are available to students (both undergraduate and graduate) to carry out exercises and assignments.

Progress

We presently operate 25 workstations spread about in Borlaug Hall and the Soils Building. Thirteen of these workstations, including five AT servers, were initially provided by the Woksape grant. The workstations are located in labs, classrooms, and offices. With the existing wiring and Multi-Station Access Units (8228s) we can expand up to 40 sites over the next year.

To date, the Token Ring has been used in four classes offered by the Department of Soil Science:

1. In *Soils 5230, Soil-Plant-Water Relations*, students were asked to run a computer model to estimate soil hydraulic conductivity based on varying soil physical properties. The instructor, Dr. James Swan, monitored the model and data bases from a server and had the students run the model in small groups from various workstations. This activity is expected to increase among the soil physics staff to the point where such laboratory exercises will become a significant part of the courses.

2. In *Soils 3220, Soil Conservation and Land Use Management*, students were asked to interpret soil properties related to erosion, tillage systems, and land use based on digitized soil maps accessed through the Token Ring System and used with graphics software. The chief advantage provided by the network is centralized storage, such that soils maps (each several megabytes in size) and software to use them can be managed

from a server and made available to each workstation without affecting its memory capacity.

3. In *Soils 5228, Seminar in Climatology, Meteorology and Agriculture*, Token Ring workstations were used to access a centralized climate data base and graphically display trends and cycles in Minnesota's weather. James Zandlo, State Climatologist, used the enhanced graphics facilities to show, by means of slow-motion graphics images, the dynamics in trends and cycles of weather over the past 100 years. For this purpose, a Sony Color Video Projector was linked to a workstation in the classroom, where the graphics generated by a server could be projected on a large screen. This demonstrated the processing power of a relatively low-cost portable workstation when it is linked to the Token Ring System in a classroom setting.

4. In *Soils 5424, Applied Climatology*, Dr. Donald Baker used the CERES-MAIZE crop growh model, developed at Texas A&M University, to show students the impact climate has on crop growth, development, and yield. The model was maintained on one server, while the various data bases used were kept on a second.

In addition to the specific uses of the Token Ring System described above, workstations have been made available to our 50+ graduate students and 40+ undergraduates. Use of shared memory, printer, storage, software, data bases, and color plotter have been assets in boosting student productivity and the quality of work being done.

Future Plans

Future application of the departmental network includes a new course offering next fall quarter entitled Soils 3104, Computer Applications in Soil Science. This course, taught by Dr. Pierre Robert, will be based primarily on laboratory exercises for token-ring workstations. Topics to be covered include problem-solving modules in soil survey, management of soil physical properties, climatology, soil fertility, chemical transformations, and soil microbiology. Students will also become familiar with such software tools as spreadsheets, relational data bases, graphics, and simple models. Dr. Terry Cooper has received a single-quarter leave to develop additional Token Ring Network applications for his course offerings, including Soils 1122, Introductory Soil Science, and Soils 3520/5510, Soil Morphology, Classification, and Genesis.

Recently, a gateway to St. Paul Computing Services was established via an ITE-12/DOB2 interface. The IBM 4381 mainframe will be used for a variety of applications out of the Token Ring Network, including BitNet access, Nomad II database management, real-time weather data collection and processing, geometric correction software for digitized soil maps, three-dimensional graphics processing, and others.

We have been approved for the addition of IBM PS/2 Model 50 and Model 60 computers. These systems will be linked to the Token Ring Network later this fall. The Model 60 is intended to function as a server where several large data bases can reside. The Model 50 will be used by Dr. Allan in teaching an advanced plant nutrition course this year. Both models will allow us the opportunity to test what will likely be popular PS/2 servers and workstations for token-ring environments.

As one of the larger Woksape projects in the College of Agriculture, we are especially cognizant of the need to communicate what we are learning. In this context, we have exchanged information with the School of Management, College of Forestry, and Department of Geography in the College of Liberal Arts, as well as other departments in the College of Agriculture. We will also be hosting two international meetings during the next year, one in Soil Survey and one in Soil Mechanics. Use of the Token-Ring Network System will be addressed at these meetings.

Equipment

6 PC/ATs with Enhanced Graphics displays
4 PC/XTs with Enhanced Graphics displays
2 PC/XTs with Professional Graphics displays
1 Professional Graphics display
1 PS/2 Model 50 with VGA display
1 PS/2 Model 60 with VGA display
10 Proprinters
3 Colorjet printers
1 Color plotter
1 PC/Convertible
PC Network

Project Number: AG07

Simulating Landscape Change: Image Capture

Joan I. Nassauer, Lance Neckar, David G. Pitt
Department of Horticultural Science and Landscape Architecture

Purpose

The project will place in the classroom a visual simulation system (VSS) that links video and computer technologies with an image-capture system. The system will enable students of landscape planning and design to manipulate video-generated images (either on tape or on videodisc) with the computer, in order to assess the visual qualities of proposed landscape changes. Funding will be used to share data, images, and equipment; to develop courseware; and to integrate hardware and software into classroom instruction.

Students will learn how to represent landscape change with the VSS in LA 3101 (Communicating Landscape Quality). They will use the system to represent change and to gather data on public perceptions of change in LA 5103 (Urban Landscape Design), 5105 (Recreation Planning and Design), and 5107 (Regional Landscape Design). In the latter two courses, data on perceptions of sample landscapes will be gathered with the VSS, generalized to the entire landscape "population", and computer-mapped using a geographic information system (GIS) that is the result of a related Woksape project (AG01).

Visual simulation systems have been developed at only a handful of universities. None uses the proposed IBM InfoWindow technology or links data on public landscape perceptions with GIS mapping or formulation of broad public land-use policy. The integrity of images generated with this system could advance measurement of public landscape perceptions by creating standard tools for environmental impact assessment.

Progress

Over the project's two-year duration, we were granted three IBM PC/ATs. Two of the ATs were configured with memory expansion, optical disk storage, data-tablet input devices, high-resolution, color displays, AT&T Truevision Image Capture Boards, and Lumena image-processing software. These ATs were connected to a three-tube RGB video camera to create two video-simulation-system (VSS) workstations. The third AT was configured to support the DDD-10 three-dimensional solid-modelling graphic system developed under Woksape auspices by Professor Lee Anderson, Director of the Computer-Aided Design Studio in the School of Architecture and Landscape Architecture. Imagery generated with DDD-10 can be read as input files into the Lumena system for further processing. The three workstations enable entry and manipulation of user-generated computer graphics as well as entry and manipulation of imagery from photographic, slide, or video media. Processed imagery can be output in slide and video formats.

To date, the VSS workstations have been used to simulate landscape change, primarily in rural settings. Six graduate and one undergraduate students have been trained as workstation operators. The seven students have completed projects depicting the impact of camper behavior on campground quality in the Boundary Waters Canoe Area Wilderness, the implementation of the Reinvest-in-Minnesota land-conservation program in southeastern Minnesota, and the restoration of prairie wetlands in the Red River Valley. The students' work in landscape simulation has won awards for landscape communication from the Minnesota Chapter of the American Society of Landscape Architects (ASLA) and has been nominated for a national ASLA award. The students' work has enabled natural-resource managers from the U.S. Forest Service, the U.S. Fish and Wildlife Service, and the Minnesota Departments of Natural Resources and Agriculture, respectively, to visualize the landscape consequences of resource-management decisions they must make.

The image-capture workstations have been integrated into the studio experiences of three undergraduate courses in landscape architecture. Students in the Fall '87 offering of Urban Design (LA 5103) developed video simulations to depict design proposals for Cedar Avenue in downtown St. Paul. In the Fall '88 offering of Regional Landscape Design and Planning (LA 5107), students used the VSS workstations to simulate the landscape consequences of key provisions of the Food Security Act of 1985 (FSA). A slide program depicting the simulations was prepared and presented to local and state officials in rural southeastern Minnesota, the setting of the project. The slide program explained provisions of FSA and presented several planning alternatives for managing the landscape implications of FSA. Similar image capture applications are planned for LA 5107 during its Fall '89 and Spring '90 offerings.

During Spring '89, students in Communicating Landscape Quality (LA 3101) were trained to use the image-capture workstations. Students prepared simulations depicting design proposals in various landscape settings. This introduction to the use of image-capture technology has been integrated into the syllabus of LA 3101.

Based on the summary of project activities reported above, Project AG07 can report accomplishment of its major objectives. Two VSS workstations are fully operational, and image capture has been integrated with Professor Anderson's solid modelling system. Image-capture technology has been used to depict landscape change in three rural Minnesota settings for state and federal land-management agencies. Image capture has been successfully integrated into the syllabi of three undergraduate courses in landscape architecture.

Equipment

1 PC/AT with Professional Graphics display
1 PC/AT
1 Color plotter
1 Colorjet printer
1 Tabletop scanner
2 Optical disk drives
PC Network

Project Number: AG08

Computer Assisted Instruction Software for Sensory Testing of Foods

Zata F. Vickers
Department of Food Science and Nutrition

Purpose

Two computer tutorials and a simulation developed for this project will be used in the course FScN 5360, Sensory Evaluation of Foods; this course covers the test designs and methods used to study the sensory qualities of foods. The tutorials will present information on statistical hypothesis testing, type II errors, and power calculations. These tutorials will serve as a review of concepts students should have learned in prerequisite courses, and will also introduce new concepts of specific interest to sensory testing of foods. Presenting these concepts involves considerable use of graphical displays and, in some cases, moving and/or overlapping the displays. The computer tutorial is an ideal tool for presenting this statistical material because of the graphic nature of the subject, the need to move and overlap the graphic displays, and because students will differ in the amount of time and effort needed to review the material.

In addition to the tutorials, a simulation will mimic the design and analysis of several sensory tests. Sensory tests are time-consuming to conduct in practice and, although we do conduct them in the laboratory accompanying this course, we conduct most tests only one time and are limited in the number of human subjects we can test. The proposed simulation would provide for active learning that is currently beyond the scope of the course. By having a computer to run the tests and analyze the data, the students will be able to devise their own experiments and observe the effects of changing different features of a sensory test design on the results of the tests and their interpretation.

Progress

All three software products have been designed and are currently being programmed.

Equipment

1 PS/2 Model 50 with VGA display
1 Proprinter

Project Number: AG 09

Interactive Video Tutorials for Principles of Nutrition

Dennis Savaiano
Department of Food Science and Nutrition
Patricia Swan
Graduate School

Purpose

The purpose of this project is to develop a series of self-study tutorials dealing with certain aspects of the subject matter taught in a college-level elementary course in principles of nutrition. We have expanded this purpose to include developing tutorials that may be appropriate for in-field training of educators, health-science students, and others with an interest in the principles of nutrition. These tutorials were originally proposed in response to the need of many of our students for additional approaches to the study of nutrition principles. The tutorials will use level-3 (computer-driven) interactive videodisc technology. The main advantage of this technology is the ability to integrate video images (and audio) with computer-based instruction (CBI), thereby dramatically increasing the kinds of material that can be presented to the student and the possibilities for interactive learning.

Progress

We have made progress in several areas, but much additional work remains. Progress to date includes:

1. Funds and equipment have been obtained from Project Sunrise (College of Agriculture), Department of Food Science and Nutrition, and Project Woksape, as follows:

   Sunrise:

Faculty release time	$ 5,086
Instructional Design	1,000
Artwork	500
Programming	3,500

   Food Science and Nutrition:

Lasererdisk preparation	700
Photographer	(staff time)

   Woksape (equipment only):
   IBM PS/2 Model 50
   InfoWindow system
   Software (Learning System)

2. Images were photographed for the initial tutorials on energy in foods and human energy requirements. These images (approximately 140) were placed on the USDA Shared Disk #2. The disk has been produced, and we have a copy.

3. Tutorials on energy in foods, energy requirements of humans, exercise, and energy needs have been outlined.

Future Plans

An unexpected sabbatical leave (5/16/89-5/15/90) has reduced this P.I.'s effort on this project. The project is being continued by Peter Tallas, Assistant Professor and Extension Specialist, Department of Food Science and Nutrition. The next steps are to 1) become familiar with the authoring software, 2) obtain the services of an instructional designer, and 3) begin to map out the "pages" of the tutorials on energy in foods, exercise, and human energy requirements. Also planned is a continued effort to work with the American Institute of Nutrition in developing a slide set on human nutrient deficiencies. This set would form the basis for one or more additional tutorials.

Equipment

1 PS/2 Model 50
1 InfoWindow system

College of Biological Sciences

Impact of Project Woksape on the College of Biological Sciences

Richard W. Peifer, Associate Education Specialist, General Biology Program

The diversity of subjects awarded Woksape funds represents a broad cross-section of the biological sciences, with plant taxonomy, molecular biology, behavioral ecology, limnology, population dynamics, and evolutionary biology represented. Five Woksape projects were funded in 1987, bringing the total to six (one from the previous year) in the College of Biological Sciences (CBS). Most of the newly awarded projects deal with theoretically abstract topics that are often difficult for students to conceptualize. Dimensions of space and time outside everyday experience are usual components of these topics. It should now be possible to accelerate and enrich the learning of these concepts with the aid of computers that can handle mathematically complex and tedious computations, and graphically display the processes or outcomes. In addition, graduate students and faculty will benefit by having the tools to probe these ideas to greater depth and understanding.

The only project well underway is the computerization of the vascular plant section of the University of Minnesota Herbarium, funded last year. Most programs have been written and preliminarily tested. Only data entry of the approximately 150,000 Minnesota specimens slows down its implementation in upper-division taxonomy courses, and in graduate and faculty research projects.

Projects awarded Woksape funds this year are now gearing up, with some waiting for equipment, while others have just received the last of their equipment. Some principal investigators, such as Dave Tilman and Don Alstad, hope to have preliminary programs running in some of their ecology courses this winter quarter. Others, such as Bob Megard, hope to have equipment and programs ready for the core ecology course taught at Lake Itasca this coming summer. Without exception, all principal investigators are excited about the new frontiers these grants open for teaching and research.

The College of Biological Sciences and its departments have also been supportive of the Woksape projects. Funds to establish a computer lab, equipped with six PS/2 Model 50 computers and supporting equipment to test Woksape software, have been provided by the Dean's office. Graduate teaching support is being provided by one of the departments to help coordinate some of the projects. Miscellaneous equipment, such as echosounding recorders, has been provided by departments and the Dean's office. Resources from the CBS Molecular Biology Computer Facility, soon to be established, have also been pledged for the molecular graphics modeling projects.

Enthusiasm is high among the principal investigators. The projects look innovative and workable. If the projects succeed, they will have added a new and exciting dimension to teaching and research within the biological sciences.

Project Number: CBS01

Computer Data Base System for Vascular Plants

Clifford Wetmore
Department of Botany

Purpose

This database system provides ready access to the label data for the vascular plants in the University of Minnesota Herbarium. Parts of the system are based on the computerization of lichens begun in 1973 using punch cards for data entry. The new system for vascular plants includes many additions to make data retrieval easier for those who do not know the details of mainframe computer database operation.

The data base will be located on a Cyber mainframe computer at Lauderdale and will use the database management system (DBMS) called System 2000. Access by phone line will be provided so sections of the main data base can be transferred to a microcomputer where a DBMS called r:Base System V is used to look at the data. R:Base is entirely menu driven, so the end user does not need to know much about either of the database systems to retrieve information. The end user will not be able to modify the main data base, but will be able to get label data from any specimen or any political area and print reports from any retrieval.

The first part of the system is the data-entry program written in BASIC called VASDAT. This program asks for the different parts of the label data and then checks for errors, including spelling of taxa, collector names, and counties; looks up the family name; and writes the data to files for loading into the main data base.

The main data base (System 2000) includes separate fields for family, genus, species, subrank, infraspecific name, state, county, area, locality, collector, collection number, collection subnumber, date of collection (separate fields for day, months, and year), notes, fertility state, type designation, and accession number. Data can be retrieved by any combination of fields except the note field.

R:Base System V has menus where simple selections of options will carry out all of the retrievals, including getting sets of data from the main data base. The first few options will request data from System 2000 for loading into R:Base. Control is then transferred to a communication program (CONNECT) that sends the request to the main data base, gets the data, and brings back the files of data. Program control then returns to R:Base and the data are loaded into the local data base, where the user is presented with the menu for viewing the data. Options are available to look at all taxa, all records of one species, or all label data for one specimen. Other retrievals can list all collectors at a locality or get data and plot distribution maps of species.

This database system is not meant to replace viewing the actual specimens. For example, it is not possible to include all the ecological information on the label in the data base. This system will provide easy access to most of the label data, so that only a few specimens of particular interest need be examined. It also will provide many kinds of summaries that would be nearly impossible to get without the data base, such as a list of all collectors and all taxa for an area.

Progress

Programs have been written for data entry, Cyber and microcomputer database definitions, communication with the Cyber, and data retrieval. The data-entry programs were written in BASIC, but most of the other programs are adaptations of commercial software. All program units have been tested and data entry has begun. Because the system is still in the development stage, most modifications can still be added.

Future Plans

Later in the project, photographs of representative specimens of each species will be added to the data base, so a picture of the species can be viewed on the computer screen. Provision is also included for mapping specimens by exact locality, but these programs do not yet exist for microcomputers.

Further testing, modifications, and data entry are planned for this year. In the Spring Quarter of 1988, a seminar will be given to teach how to use the system and to describe its design, so applications can be designed for other data bases.

Equipment

2 PC/ATs with Enhanced Graphics displays
1 Color plotter
2 Proprinters
1 Monochrome display

Project Number: CBS02

Teaching Software for Population Biology

Donald N. Alstad, Peter Abrams, James W. Curtsinger, and G. David Tilman
Department of Ecology & Behavioral Biology

Purpose

We propose to write a package of interactive instructional software illustrating the conceptual bases of population dynamics and evolutionary biology. Abstract mathematical models, a central feature of this science, can be graphically simulated with a microcomputer, facilitating visual and intuitive understanding that is extremely difficult to achieve in the lecture hall. A wide range of interests among the collaborating PI's will result in a diverse package of compatible programs that will see application in the CBS Core Curriculum course in Ecology (Biology 5041) and four advanced courses, providing hands-on experience to 300-400 students per year.

Progress

Five PS/2 Model 80 machines for our Woksape project were delivered in August; external drives, video memory boards, 80387 coprocessors, and plotters have not yet arrived. Significant non-Woksape resources have also been assembled to support the work. Our departmentally-funded teaching assistant will be D. Gordon Brown, a doctoral student in Ecology and Behavioral Biology, will defer the third year of his National Science Foundation pre-doctoral fellowship to participate in the project. The College of Biological Sciences and the EBB Department have also invested $22,000 for six System 2 Model 50 machines and supporting equipment for a computer lab to pilot Woksape software. These resources establish a solid foundation for our project; we are eager to have the remaining equipment in place and to get programs running.

Future Plans

We will develop simulation software for population models presented in Biology 5041, the core ecology course for majors in the Biological Sciences, and for four advanced courses (EBB5052, EBB5063, EBB5065, GCB5033) within 15 months after installation of equipment. An abbreviated summary of the models that will be developed for each advanced course is given below. Those programs that will also be appropriate for the Biology 5041 core course are marked with an asterisk*. Each of these models has rich dynamic behaviors that cannot be easily explained or visualized in the lecture room, but could be learned through an interactive process and readily visualized using the graphics capabilities of microcomputers.

1. EBB5052 - Theoretical Population Ecology - Dave Tilman

   a. A model of population growth in limited environments, illustrating differences between the dynamics of populations where reproduction is synchronous and seasonal, and populations that reproduce continuously.

   b. Models of competition for limiting resources among species living in limited and unlimited environments; and competition among size-structured organisms, such as plants, which are limited by light and a soil nutrient.

2. EBB5063 - Evolutionary Ecology of Insect Populations - Don Alstad

   a. A basic simulation model of evolution by natural selection, projecting the changing frequencies of genes with different patterns of expression and relative fitness.

   b. A model of the balance between selection on individuals and selection on groups, exploring conditions required for the spread of an altruistic trait that is bad for the individual, but good for its group.

3. EBB5065 - Theoretical Evolutionary Ecology - Peter Abrams

   a. A model to simulate growth in an ''age-structured'' population composed of younger and older individuals with different birth and death rates, and calculate the optimal life history of an individual with specified tradeoffs between reproduction, growth, and survival.

   b. A model simulating trait dynamics and evolution in interacting populations in which some of the properties of individuals are adaptively variable.

4. GCB5033 - Population and Quantitative Genetics - Jim Curtsinger

   a. Models simulating the relative importance of chance processes and natural selection in populations of different size. The programming will involve storage of ''chromosomes'' in memory, and repeated sampling by generation of random numbers.

   b. Complex models dealing with several different genes simultaneously, and simulating the effect of interactions between recombination, natural selection, population size, and effects of each gene on the expression of others.

Equipment

5 PS/2 Model 80s with 8514 displays
5 Color plotters

Project Number: CBS03

Software Development for Display and Analysis of RNA Structure

Perry B. Hackett
Department of Genetics and Cell Biology

Purpose

All of the information required for the form and function of cells is encoded in genes that are composed of DNA. When specific information is needed to make a certain protein, a particular gene (or genes) is copied into RNA. The process of decoding the information in RNA to produce protein is called translation. RNA molecules are composed of hundreds to thousands of bases, the fundamental unit of nucleic acids. RNA can fold into extraordinary convoluted patterns according to a few basic rules. To date, except for a very few RNA molecules that are only about 100 bases in length, we understand the functions of RNA only in terms of the linear sequence of bases in a particular molecule. Very little work has been done on the effects that the folded structure of RNAs may have on translation and other interactions of RNA with proteins.

The goal of this project is to develop software that will allow students and researchers to ''see'' RNAs in terms of their important structural and genetic properties. Programs will be developed in two parallel forms. One version, designed to run on an IBM PC/AT, will be oriented toward students and used as a classroom teaching tool. In this respect, the programs will be used in conjunction with the Recombinant DNA Laboratory course (Biol 5125) offered three times each year. The second, scaled-up version will run on an IBM PC/RT computer to take advantage of increased speed and memory required to accommodate larger and more complex RNA molecules that researchers want to study. This software will incorporate several different algorithms for RNA folding into one program, in order to compare the important folding patterns for a particular RNA and to determine those structures that are ''conserved'' using the various folding theories.

Progress

We received a Personal System/2 Model 80 with color display in late July 1987, but have not yet received the math co-processor and modem. Consequently, we have been unable to actually modify existing programs for the folding of complex RNA structures.

The major programs are written in FORTRAN, requiring a math co-processor for modification. Since July 1, we have examined those existing programs, determining presumptive color codes to enhance the biological information in the folded molecules. We have begun writing program modifications (untested) for cleaner and unambiguous folding and window applications to allow blowups of localized regions of interest. When the rest of the hardware is available, the project will proceed.

Equipment

1 PS/2 Model 80 with VGA display
1 Color plotter

Project Number: CBS04

Interfacing Microcomputers with Sonar Equipment for Teaching Aquatic Ecology

Robert O. Megard
Department of Ecology and Behavioral Biology

Purpose

The purpose of this project is to connect microcomputers to echosounders so that students can study the small animals suspended in lake water (zooplankton) much more efficiently than is possible with conventional methods. The computers will be interfaced with commercial echosounders that are widely used for sport fishing. These echosounders use an acoustic frequency (190 kHz) that detects not only fish but also small organisms in the size range (0.5 - 5 mm in length) of zooplankton, which are important food for most young and many adult fish.

The echosounders emit short acoustic pulses, typically 0.1 msec in duration, at a rate of three pulses per second. Sound reflected from various depths is recorded as voltages that depend upon the depth, size, and concentration of the plankton and fish. Hundreds of such echo voltages are returned from each sound ping. The central problem is to develop system software for digitizing the echo voltages and controlling the acquisition, display, and analysis of the digital data.

Students normally use the equipment to record acoustic data along transects across lakes. Data are displayed instantaneously in color on the computer screen. In the laboratory, students can replay and study the color echograms, plot echo profiles from individual pings, or create contour plots that show plankton concentrations numerically at all depths along transects.

Progress

The system hardware consists of an IBM PS/2 model 30 microcomputer powered by a 100 amp-hour lead-acid automotive battery through a DC/AC invertor, a Data Translation DT-2801A data-acquisition board, a modified Lowrance X-16 echosounder equipped with narrow-beam and wide-beam transducers, and an IBM model 3363 WORM optical disk drive.

The model 30 microcomputer was selected for its small size, light weight, low cost, and compatibility with currently-available data-acquisition boards. The computer has a 20 mb hard disk and a VGA graphics adapter, which displays echo strengths at a resolution of 640 x 480 pixels on a 12-inch PS/2 color monitor.

The only modification of the echosounder was to make two connections to its circuit board, one for the signal that triggers the acoustic pulses, and the other for the echo-voltages returned from each pulse. The pulse-trigger signal is the input for the external trigger line of the data-translation board that starts the A/D sampling for each ping. The echo voltages are input to one of the A/D channels of the data-translation board. The voltages are digitized at sampling rates up to 28 kHz.

A double-buffered Direct Memory Access (DMA) data-collection technique is used to permit display of the data in real-time. While echo voltages from a pulse are being digitized in buffer 1, the software processes, displays, and stores data in buffer 2 that were collected from the previous pulse. Assembly-language routines were developed to display a color rendering of the digitized echo strength in real-time on a scale of 4095 digital units. The software uses pull-down menus to allow the operator to select parameters for the collection and display of data. The data files from acoustic transects often are 2 - 5 mbytes in size, so they are copied onto 200 mbyte optical disks and then deleted from the hard disk to make room for new data.

The system was first used during the summer of 1988 by students in an ecology course taught at the University of Minnesota Forestry and Biological Station located at Lake Itasca. Procedures for using the system to study natural populations of plankton and fish were developed and tested extensively during the 1988-89 academic year at the Lake Kinneret Limnological Laboratory in Israel, with financial support from a Bush Sabbatical Award and a Fulbright Research Award.

Future Plans

The system will be used again for teaching aquatic ecology to undergraduate students at Lake Itasca during the summer of 1989. It also will be used in a workshop for teachers at Lake Itasca in September, 1989, and to teach a variety of courses after that. Beginning in July, 1989, it will be used for research on the plankton and fish in some Minnesota Lakes, on a project sponsored by the Minnesota State Legislative Commission for Future Resources. This will provide opportunities for graduate students to use the system and also provide financial support for additional programming and hardware to facilitate the analysis and interpretation of data.

Equipment

1 PS/2 Model 30 with VGA display
2 PS/2 Model 50s with VGA display
1 Proprinter
1 Optical disk drive

Project Number: CBS05

Teaching Software for Behavioral Ecology

Craig Packer
Department of Ecology and Behavioral Biology

Purpose

Behavioral ecology is, in effect, an extension of population biology into the field of behavior. Behavioral traits interact with genetic, demographic, and ecological processes to shape populations. Most population biologists, however, ignore the fact that an apparently beneficial behavioral trait may not be evolutionarily stable, since it is prone to invasion by an alternative strategy. It is this interaction of alternative strategies that makes game theoretical analysis an integral component of population models.

Game theory provides an important conceptual basis for the new field of behavioral ecology, and has been successfully applied to problems as diverse as the evolution of fighting strategies, cooperation and altruistic behavior, and the sex ratio. Game-theoretical models are computationally tedious, however, because they require monitoring of simultaneous changes in a large number of formulas. Further, although it is a major foundation of the field, there are considerable difficulties in conveying game theory to students who are generally surprised and uneasy encountering algebraic models in a course on behavior. In the absence of hands-on access to computers and the appropriate software, most students derive only a superficial comprehension of the ideas being taught, and very few gain the motivation to try out models on their own. The development of software for classroom instruction will have great impact in improving students' comprehension, confidence, and motivation.

Future Plans

Programs developed for this project will be modular and interactive, and designed to work in unison with those developed in another Woksape project, CBS02. Hence, the work will be useful to the same 300-400 students per year, as well as to an additional body of students with a particular interest in behavior. The software will introduce game-theoretical models to students in the core ecology course in the biological sciences (EBB 5041), and more sophisticated techniques for the advanced course in Behavioral Ecology, EBB 5325. It will use variations of the Hawk-Dove game to illustrate a possible pathway to complex fighting strategies in contemporary populations. Simulations will show the dynamics of several strategy games. Graphical presentation of the simulations will clearly convey how factors affecting each payoff influence movement to the most stable strategy.

A package in population biology that includes behavioral ecology will be both timely and unique, as well as more truly comprehensive than anything available at present. Software focusing specifically on game theory is not currently available and could be shared with other universities, since the approach is not yet being fully exploited by behaviorists in the United States.

Equipment

1 PS/2 Model 80 with 8514 display
1 Color plotter

Project Number: CBS06

Protein Molecular Graphics Software for IBM Personal Computers

Clare Woodward
Department of Biochemistry

Purpose

The aim of the project is to develop software for interactive molecular graphics on a PS/2 Model 80 computer. Specifically, the software will support 1) interactive display and design of the chemical structure of proteins, 2) networking personal computers with molecular modeling programs running on a microVAX and/or SUN computer, and 3) networking between personal computers for group instruction in a classroom environment. The project will be supported as well by resources in the molecular graphics facility soon to be established in the Molecular Biology Computer Facility of the College of Biological Sciences (CBS) and from research grants.

The software proposed here will be immediately applicable to the graduate course in biophysical chemistry. In addition, availability of the software could form the basis of graduate and undergraduate courses in protein structure/function and modeling. These would be important additions to the biochemistry program of the University of Minnesota. Finally, the software will be suitable for use in the computer classrooms being built on campus.

Progress

This grant has just been awarded. The computer has been ordered. Significant portions of the design have been completed, and programming will proceed as soon as the Model 80 arrives.

Future Plans

The central idea of this project is to make low-cost molecular graphics display and modeling capabilities for large biological molecules available for instruction on personal computers. The software will be developed in three modules: 1) display of the protein molecule, 2) alteration of the protein molecule, and 3) evaluation of the molecule. The display utility may be used alone or in conjunction with 2) and 3). Each module is further described below.

1) The display program will show lines (bonds) connecting points (atoms) defined by the x,y,z coordinates of a known structure. The protein structure may be rotated in incremental steps, with step interval and axis of rotation entered from the keyboard. The program will include utilities for enlargement or reduction of specified sections of the molecule, and for color coding of specified atoms.

2) Interactive alteration of the model is a second module. After alterations are made, the program will calculate the new atom positions as x,y,z coordinates and store them for computations (step 3). Changes are made by rotation of atoms about a covalent bond (line), or by docking (joining together) new segments. For the latter, one needs two independently movable molecules on the screen.

3) The chemical reasonableness of the new structure will be tested by running it through a specified number of cycles of energy minimization and/or molecular dynamics. We now have this package running at the University on a VAX and a CRAY XMP. The new x,y,z coordinates are data for this operation. If possible we would like to be able to do the minimization on-line, and then display the result by color coding the interaction energies of each atom (e.g., red for bad contacts or high energy, merging to blue for good contacts or low energy).

Equipment

PS/2 Model 80 with 8514 display
1 Color plotter
1 Proprinter

Project Number: CBS07

Knowledge-Based Simulation and Explanation of Protein Folding

Peter N. Saurugger
Department of Botany

No report was submitted for this project.

Equipment

1 PS/2 Model 80 with 8514 display
1 Proprinter

College of Liberal Arts

Impact of Project Woksape on the College of Liberal Arts

Jean E. Cameron, Assistant to the Dean, Curriculum Coordinator

Project Woksape has had a great effect on the teaching of many disciplines in the College of Liberal Arts. Faculty members who had little previous experience with computing have developed innovative software, often software that is on the cutting edge in their disciplines.

Because of the work done by faculty on Project Woksape, students in beginning logic courses can now program their logic sentences in a customized programming language. The sentences are then analyzed by the computer to see whether the logic is correct. These features of being able to easily program the sentences and to have instant analysis of the logic provide a much more active learning environment than is usually available to students in large introductory logic classes.

Several natural languages are now taught using computers for various kinds of drill. Students use computers on their own in labs, freeing classroom time for professors and teaching assistants to work with students on other, more complex aspects of language learning. Students can then build on the base provided by the computer-drill work to enhance their other classwork.

As a result of Woksape funding, students are also able to study sociological principles using simulation games that demonstrate how decisions affect (and effect) outcomes. Other students manipulate data sets with statistical packages and use the resulting data in papers they write. Students taking General Psychology can be tested using a testing instrument that selects the proper questions to ask and scores the tests more quickly and accurately than was possible before.

History students can test hypotheses using census data and discover whether their projections of results from changes in the data are accurate. Students in several social-science fields now use computers to aid them in various methods of studying statistics.

Professors teaching writing skills in several disciplines employ new programs that aid students in organizing their thinking and writing. Students in other disciplines study speech analysis and hearing disorders using self-paced, computerized instruction.

Mapping instruction is also accomplished using various computerized techniques, so that students can learn several ways to create maps.

These examples illustrate some of the many and varied ways in which Project Woksape has contributed to the excellence of instruction in the College of Liberal Arts at the University of Minnesota.

Project Number: CLA01

A General Purpose Curriculum Delivery System

Jean Cameron
College of Liberal Arts

The purpose of this project is to produce a general-purpose curriculum-delivery program to aid teachers and students in upper-level university courses. The goal is to develop the software in such a way that it will allow various departments to develop their own discipline-based core curricula with an extensive writing component. This shell, ACCESS, has been pilot-tested and applications have been developed in several departments within the College of Liberal Arts. In the following pages are presented brief summaries of individual projects that benefit from this overall effort.

1. ACCESS: A Computing Environment for Composition Courses: Donald Ross, Jr., Department of Composition and Communication; and Sheldon Fossum, Computer Design Systems

Purpose

To address higher level learning skills, we have developed a set of programs, called A Computer Composing Educational Software System (ACCESS), which let teachers design any lesson, exercise, or assignment they wish. The exercise is prepared for the student, who writes answers on a file using a simple word processor that we have also written. Since our concern is to have university students write essays and similar longer pieces, we concluded early on that the student's output could not be automatically evaluated. The file that the student produces is therefore printed and read by the teacher or by other students in a peer conference group.

Progress

ACCESS became available in September, 1986, through the University of Minnesota's Media Distribution Department. Exercises are now available for a wide range of composition courses, from case-study assignments for business writing to a full suite of suggestions on how to get an assignment started and organized, to explorations of patterns in literary works. They range in complexity from a few screens in a linear pattern to "START," the invention package: its screens take up over half a disk, and it has elaborate branching. The teacher can select from a variety of textbook approaches to planning and have students run through exercises in a defined way. Students can pick a particular exercise that helps with a specific assignment, or make choices based on their own composing style.

During 1986-87, we have developed additional exercises. For courses in technical writing, Professor Ann Duin on the St. Paul campus has built a comprehensive planning package for feasibility reports, keyed to the particular majors whom they teach. An interview exercise moves from selecting interview subjects and deciding on the questions to a formal report on what the interview taught the student.

For students in literature courses, Laura Brady and Tim Sweet have developed an exercise to help students classify and annotate a bibliography of criticism. Professor Ross has completed work on an experiment in presenting Thoreau's Walden to undergraduates. This involves nine key paragraphs, journal drafts, critics' commentaries, and biographical data. The student sees the paragraphs as menus and, by selecting a given path, may be asked to write a brief essay, compare passages, or just learn some background information.

Future Plans

In the next year, we hope to involve instructors from other humanities disciplines in developing exercises. ACCESS has been intentionally designed for any setting where extended student writing is desired, not just composition courses, so the problems should continue to be the interesting ones -- conceptual, intellectual, and cognitive -- issues that will challenge teachers and, through them, their students.

2. Latin American Studies: Stuart Schwartz

Purpose

The director of the program, Professor Stuart Schwartz, has been consulting with programmers to have statistical packages written for use by students taking courses dealing with Latin America. Students can then write papers on such topics as education or economic changes over the last 20 years. Basic information on the topics will be stored on diskette, and students will then be able to manipulate the data statistically, in order to use the information writing their papers.

Progress

The Latin American Studies Program received an XT during the last year, and just recently received two PS/2s for student use. The student machines will be placed in the Department of History student lab, so that there will be security for the machines.

The initial work of designing the data bases has been accomplished this year, as have discussions with programmers concerning the design of the modules.

Future Plans

Professor Schwartz expects the programmers to begin working shortly on the project, so that students can begin to use the materials as soon as possible. He will be evaluating ACCESS in the near future, in hope of setting up a writing module for his students.

3. Philosophy: William H. Hanson

Purpose

The purpose of this course is to develop materials to be used in beginning logic courses.

Progress

Professor Hanson has been working on this project in stages. The first stage has included using existing software in beginning logic classes in order to test the efficacy of such software and gauge students' learning.

This summer, Professor Hanson taught Phil 1-001, Introduction to Logic, to about 60 students, and had them work exercises and prepare homework on the computer. The programs they used are supplements to the text, Logic: A Computer Approach. Students worked exercises in constructing truth tables, translating arguments of English into the notation of symbolic logic, constructing formal proofs, and applying certain logical algorithms. He found the programs used were far superior to the usual paper-and-pencil homework. Students learned from the programs and were enthusiastic about using them.

This fall, he will use the same format with about 180 students. Unlike the earlier version, however, this software version has been modified to include Professor Hanson's exercises.

Future Plans

Testing these programs will enable Professor Hanson to move into the last phase of development, that of devising his own software for use in Phil 1-001. A grant from the Office of Educational Development Programs will enable him to develop the software. The software will involve students more actively than the usual CBI programs by having them ''teach'' a computer what they are learning in the course. Students will be provided with a simple programming language and some basic subroutines to use for this task. Project Assist is involved in planning this project. The possibility of using ACCESS is also being explores.

4. Women's Studies: Naomi Scheman

This project has been terminated.

Equipment for all CLA01 projects

7 PS/2 Model 50s with VGA displays
3 PC/XTs with monochrome displays
10 Proprinters

Project Number: CLA02

Social Science Statistics Honors Course

John L. Sullivan
Department of Political Science

Purpose

Most social science departments in the College of Liberal Arts offer specialized undergraduate courses in introductory statistics, where students learn about concepts and procedures used by a particular discipline. This project developed a CLA Honors course that focuses on preparing students to deal with a wide range of substantive problems in the social sciences by conceptualizing appropriate statistical approaches to analyzing these problems. The course assumes that the most thorough understanding of statistical concepts comes from experience in applying them to many different types of problems. The IBM computer network provides students with varied social-science data sets and research problems. It allows them to conduct a large number of statistical analyses on many data sets in a manner so straightforward and efficient that it does not detract from the main purpose of the course: to teach students how to conceptualize the statistical analysis of social-science research. The success of this course led us to re-evaluate how the College of Liberal Arts offers it statistics courses.

Progress

The Honors course was offered once a year for three years. Students were confronted with a large range of substantive problems, in four different computer-assisted formats. First, they did their everyday homework using a computer-assisted instructional format developed using the authoring tool, PILOT.

Second, students worked on a series of weekly laboratory assignments using a large number of real data sets made available to them on our IBM network. They used STATA for statistical analysis and WordPerfect to write research reports. We prepared over twenty data sets for use in our laboratory sessions. All of them are real data sets collected by researchers to examine a particular hypothesis or theory. Students analyzed each data set using conventional statistical procedures ranging from simple chi-square and difference-of-means tests to regression analysis. For each statistical concept or procedure, several different types of data sets illustrated how to assess the assumptions underlying the statistical analysis, how to conduct the analysis, and what types of conclusions could be drawn. Once an analysis was completed, the student converted the tables and graphs into a WordPerfect file and wrote a short research report.

Third, students worked on problems in sampling theory using VARMINT, a sampling program we have developed that allows them to draw multiple samples from a population with known parameters. This proved to be an excellent device for teaching about sampling distributions in general, and for helping students to understand the differences among populations, samples, and sampling distributions. More than anything else we did, this exercise solidified students' understanding of the use of inferential statistics in social-science research. We have them build empirical approximations of the theoretical sampling distributions using the results of their VARMINT exercises, entering the results through DATA MONSTER, and analyzing the results using STATA

Fourth, students replicated ongoing research projects using large data sets provided by faculty members from various social-science departments. Faculty members presented their research to the students, and the students then had access to the data through our IBM network.

Future Plans

We have now prepared a full computerized record of this project. When the course materials and computer programs are used in the future, after the end of the Woksape project, they can easily be updated with new data sets, computer problems, and research projects.

Equipment

4 PC/ATs with Enhanced Graphics displays
4 PS/2 Model 50s with VGA displays
2 Monochrome displays
6 Proprinters
PC Network

Project Number: CLA03

Methods and Techniques of Social Science History

Robert L. McCaa, Russell R. Menard,
Steve Ruggles
Department of History

Purpose

In our initial proposal, the Department of History requested several IBM workstations and related equipment and software to create teaching materials designed to introduce students to the research process in social science history. We proposed assembling several data sets that could be used in a variety of courses to explore issues of historical significance marked by scholarly debate. We proposed using those materials to simulate the research process by encouraging students to interact with one another, their instructor, a body of scholarship, and a set of data in ways that would promote active learning. Students, we anticipated, would explore differences among scholars over specific issues, gain understanding of the roots of such differences, test existing arguments against some evidence, formulate new hypotheses, and test those new hypotheses against that same evidence. Not only would students acquire skills in the use of microcomputers for the management of data, but such courses would provide a means of introducing the central methods and techniques of social science and, most important, leave students with a deeper understanding of the research process.

Progress

We have made substantial progress toward these goals. Several data sets have been read into existing database management, spread sheet, and statistical software packages such as Lotus, Data Star, Condor, and SPSS. During the 1985-86 academic year, we made available for classroom use a large national sample from the 1900 federal population census; data from the population and agricultural census schedules for rural Ramsey County, Minnesota, for 1860 through 1880; biographical information on 1500 graduates of Yale College in the eighteenth century; and information on basic demographic parameters of early America that permits exploration of how migration and vital rates interacted to shape the growth of population. During 1986-87, we developed additional data sets, particularly census material from northern Mexico during the late eighteenth and early nineteenth centuries; European family reconstitution data from 1600 to 1800; and evidence on the family budgets of industrial workers in Germany and the United States during the 1890s; national samples of the federal census for the years 1910, 1960, 1970, and 1980; and census returns for the Red Lake, Minnesota Indian Reservation for 1900 and 1910.

During the past two years, we have offered six courses that centered on the use of microcomputers for historical analysis. In addition, two other courses made occasional use of Woksape materials, while several students used those materials to pursue research projects on their own. Altogether, roughly 100 students participated in the Woksape project during the 1986-87 academic year. We anticipate a modest growth in the size of the program over the next few years, although we will soon reach capacity, given our instructional methods and the available facilities.

Faculty participants in the project are enthusiastic about the results. Students, they report, benefit from the courses in several ways. Obviously, they become familiar with microcomputers and are able to put them to a variety of tasks. They also gain a greater understanding of historical research. By exploring specific issues in greater detail than is usually possible, and in a way that permits interaction with a large body of evidence, students learn how historians reach conclusions and why they often disagree. Perhaps most important, the interactive character of those courses - the ways in which students are encouraged to work closely with each other and with the instructor - generates more enthusiasm than is usually the case and leads to improved student scholarship.

During the past two years, we have spent some time communicating the results of our Woksape project to a wider audience, discussing our approach to microcomputing and instruction in social science history in faculty workshops at St.Cloud State, St. Thomas, Carleton, and Concordia-Moorhead. In addition, Professor Menard prepared a short report on the project for the Winter 1987 issue of Focus. We will continue such efforts during the next year and, as well, prepare an essay on our use of microcomputers as an instructional tool for a professional journal with national circulation.

We have invested little time in software development, but have instead concentrated on creating open-ended research packages that tie together a scholarly literature, a data set, and existing software tools to let students explore major historical issues. We have done some programming, however, ranging from elementary guides that walk students through an exercise, to more complex data-entry and bibliographic tools designed for the specific needs of historians, to sophisticated simulation routines that define the shape of kin networks in past populations. While this will remain a minor part of our effort, we will continue to write new programs and to modify existing software packages as the project requires.

Additional support for this project has come from several sources. The Department of History has provided a quarter-time graduate student, lab space, and funding for supplies; and several faculty members, particularly Professors McCaa, Maynes, Menard, and Ruggles, have devoted considerable time to the project. The Graduate School awarded a $3,000 grant to acquire a basic software library; the College of Liberal Arts funded the purchase of a laser printer; and an Educational Development Program grant allowed us to prepare instructional materials in demographic and social history.

Equipment

1 PC/AT with Enhanced Graphics display
2 PC/XTs with mono displays
2 PC/XTs with color displays
4 Proprinters
1 Quietwriter
1 Optical disk drive
PC Network

Project Number: CLA04

Computer-Aided Instruction for Hebrew

Tzvee Zahavy
Department of Classical and Near Eastern Studies

Purpose

Our project was motivated by a desire to apply to the undergraduate Hebrew language curriculum advancing ideas in educational theory in the field of education, for greater efficiency in several instructional tasks. We ultimately aim to create a synthesized environment for language instruction assisted by the computer.

Progress

We set out to create a computer-based instructional-management environment for the mastery of vocabulary and verb skills. The programs contain an overall manager, a data base, and a means for creating and analyzing student drills and performance. We determined to make the program as much as possible a tool that is generalizable to most language applications.

We took a "power team" approach to organizing the project; the team consists of a director, designer, and programmer. Our initial programmer was an advanced student in the department. The designer had a recent Ph.D. degree in education and brought to the project innovative models for learning designs. Overall, it took about two years to develop the first two modules.

Specific technical approach: Programming was done in two languages: Pascal (for both original programs) and C (for the Windows application of the vocabulary drill). We tackled the graphics and character-set problems by using and adapting available subroutines for presentation screens, and by using the Duke Language Toolkit for Hebrew-character generation for the EGA display. Because of the limitations of display, we used only unvocalized texts in the vocabulary drill and added vowels later in the verb program where they were essential.

Results for expectations: Because we had set realistic goals, we met many of our expectations. We had to contend with limitations of the academic system's rewards structure for faculty investment of time in CAI development. The project presented expected and ordinary management tasks of scheduling, communications, and budgetary restrictions. Availability of space to house the project turned out to be a major issue involving University administration. Teachers in the department had to be trained to use the program and sometimes resisted involvement. Students showed the greatest overall approval and excitement with the programs. Evaluations of its use show definite areas of effectiveness and significant gains for the students who used the programs most regularly.

Final results of this project are not in yet, because it moves forward now in the development of other modules in a joint effort with faculty in the Department of Russian and East European Studies. The broader aim is to author an umbrella program and shell for general, undergraduate language instruction. This development effort will allow teachers to select a language from available databases; select elements, such as vocabulary, nouns, adverbs, adjectives, verbs, sentences; select tasks, such as generate drill, review student progress, chart or graph class, create examination, select type of drill or examination, or generate review lists or paradigms.

Description of Software: MILIM (''words'' in Hebrew) is a user-friendly Hebrew-language drill program based on newly-developed and tested advanced concepts in language-acquisition education. With MILIM, the teacher easily prepares and transfers specified drills to a student's disk. The MILIM drill then tests the student on the words the teacher has selected, keeping track of results and recording every word that the student tries, along with the student's spelling and response time. The teacher can use MILIM to retrieve results from student exercises and to print full reports of progress with data about each drill, or in summary form with less detail. The teacher also can generate a drill summary for all students in a class to show the totals for each of the drills. The program includes a drill manager that allows the teacher to modify parameters of a student's drill (e.g., time allowed, number of repetitions); to add, edit, or delete words in the master vocabulary list; or to create and delete student drills.

The setup/install module allows the teacher control over many aspects of the program, including the option to change colors throughout the program, to insert positive and negative feedback for students, to make new keyboard layouts and key assignments, or to change the direction of the language (right-left, left-right) and language names. With this module, MILIM can be modified for use according to the needs of different teachers, and can even be adapted for teaching other foreign languages. The program can use any character set designed with the Duke Language Toolkit. MILIM is accordingly a Multi-International Language Instruction Module.

MILIM comes packaged with a master vocabulary list of over 1500 entries based on standard expectations for first- and second-year college Hebrew-language courses.

MILIM runs on any IBM PC, PC/AT, or PS/2 equipped with an EGA or VGA monitor. MILIM reports may be printed on an IBM Proprinter.

Future Plans

The current emphasis is to complete the sentence drill. A new program, VERBS, will be ready for distribution in the summer of 1989. In addition to the EGA and VGA versions mentioned above, we also anticipate developing a CGA version of the program.

Equipment

1 PS/2 Model 60 with 8514 display
3 PS/2 Model 50s with 8512 displays
1 PS/2 Model 50 with VGA display
2 PC/ATs with Enhanced Graphics displays
1 InfoWindow system
1 4216 Personal Pageprinter
1 Wheelprinter
4 Proprinters
PC Network

Project Number: CLA05

Instructional Use of Microcomputers in Teaching About Communication Disorders

Charles E. Speaks and Dianne J. VanTassel
Department of Communication Disorders

Purpose

The purpose of this project is to develop and implement microcomputer technology into four major areas of the department's curriculum: speech analysis; assessment and intervention strategies for communication and learning disorders in children and adults; simulation of audiologic (hearing) disorders; and data reduction. The basic objectives, first described in March, 1985, have remained unchanged, but there have been important modifications. One has been to expand the number of microcomputer applications originally envisioned. A second has been to dedicate multiple microcomputer systems to accommodate several students working simultaneously on a single project.

Progress

The microcomputer systems were dedicated to instructional development in 1) speech development and disorders, 2) language development and disorders, and 3) speech and hearing science. Groups of faculty from those areas assumed primary responsibility for instructional development.

Development of a *Microcomputer Instructional Laboratory*. Funds were allocated to construct and furnish a new 300-square-foot microcomputer instructional laboratory in Room 119 Shevlin Hall. The new facility will support up to ten independent work stations.

Speech Analysis and Processing. The purpose is to create a system that will support A/D and D/A conversion and provide analysis capabilities that include waveform viewing and editing, Fast Fourier Transform, linear predictive coding, pitch extraction, cepstral analysis, digital filtering, and digital spectrography for instructional laboratories in six of the department's courses. Two of the six systems acquired from Project Woksape have been dedicated to this project, and the analysis and processing systems are fully operational.

Hearing Disorders. One system has been used to run self-paced instructional programs that allow students to learn and practice five basic procedures in hearing measurement: clinical masking, decibel notation, tympanometry, basic hearing measurement, and interpretation of audiograms. Professor Van Tasell and her students in the audiology clinic designed an algorithm for fitting hearing aids.

Speech Phenomenon Identification Program (SPIP). The purpose is to provide undergraduate and graduate students with instruction and practice in the identification of and perceptual judgments about various normal and disordered speech and language phenomena. The program is operational and was used in one course in Spring Quarter, 1987. SPIP contains a number of features that allow students in groups of 1-10 to gain experience and thus increase proficiency in observing and judging specified aspects of both normal and disordered speech.

After the results of the spring, 1987 evaluation are analyzed and appropriate refinements have been accomplished, development will commence to adapt SPIP to identification of other speech phenomena.

Language Disorders. Understanding analysis of a sample of speech is basic to describing and treating language disorders, particularly with children. The department has acquired software entitled "Systematic Analysis of Language Transcripts (SALT)," which provides a framework for accomplishing such analysis. It also serves as an effective teaching tool, because it helps students to understand which aspects of language are important, how they can be coded, and how the results of such an analysis should be interpreted. SALT was used in a graduate seminar during Fall Quarter, 1986 and in an instructional laboratory in Spring Quarter, 1987.

Symposium on Instructional Use of Microcomputers in Teaching About Communication Disorders. Dr. Michael R. Chial, Associate Professor at Michigan State University, served as a Visiting Professor in Summer, 1987. He offered two courses. 1) *Microcomputers in Communication Disorders* included: fundamental concepts and terminology underpinning microcomputer; operation, capabilities, and limitations of microcomputer systems typical of those found in professional environments; applications of such systems to clinical, administrative, and investigative tasks; and development of skills for systematic evaluation of software offered for professional applications. 2) *Seminar on Applications of Speech Synthesis in Communication Disorders* included: a review of the major technologies underlying contemporary speech synthesis systems, how these relate to theories of speech perception, and methods for studying the utility of these devices from perceptual perspectives. This course relates directly to the project on Speech Analysis and Processing described above.

Future Plans

During the 1987-88 academic year, efforts will be directed at evaluating the effectiveness of these computerized systems in classroom and laboratory, making modifications, and broadening the application of these systems in classroom and laboratory situations. Modifications will result from evaluation of this year's experience, and the development of new laboratory exercises will increase the utility of microcomputers in the curriculum. For example, six additional courses in Speech Analysis and Processing will use new computer-assisted laboratory exercises.

Equipment

5 PC/ATs with Enhanced Graphics displays
1 PC/XT with Enhanced Graphics display
1 PC with color display
7 Proprinters
2 Color plotters

Project Number: CLA06

Economic Exercises Based on the Principles of Dynamic Optimization

Christopher A. Sims
Department of Economics

Purpose

The Department of Economics Woksape project integrates microcomputers into courses in economic theory and econometrics, exposing students to realistic applications of the methods they are learning. The project also integrates microcomputers with supercomputers in research efforts and in the development of software to support those efforts.

Progress

Woksape computers continued to be used in courses in applied macroeconomics, Economics 8201-3, and macroeconomic theory, Economics 8106, in ways that were not possible prior to Woksape. In Macroeconomic Theory, students determined optimal paths to bring dynamic macroeconomic variables that are initially nonoptimal back to optimality.

Professors Mark Pitt and Lung-Fei Lee continue to research the estimation of demand systems subject to inequality constraints. This subject is of considerable potential practical value, since it concerns methods for handling data arising in many marketing problems, where individuals are observed to buy none at all of some of the products available. Pitt and Lee have developed methods for estimating demand and have spent a major portion of their research time developing algorithms in portable FORTRAN on the Woksape PC/ATs.

Professors Pitt and Joel Slemrod have been using GAUSS, a matrix programming language, to develop a stochastic-sensing threshold model to estimate compliance cost of itemized deductions under the IRS code. This model is potentially useful for a wide set of such problems as labor market participation, which are characterized by the need for stochastic-censoring thresholds.

Professors Pitt and Mark Rosenzweig have used GAUSS and FORTRAN to develop a method they call FETSMDL (fixed effect two stage minimum distance logit) for estimating simultaneous equations multinomial logit models with dichotomous right-hand-side endogenous variables identified with cross-equations parameter systems.

Professor Sims continues his research on Bayesian modeling of macroeconomic time series. One branch of this work has led to the development of a three-region international model larger than any previous model of this type. A program for the AT interpolates the function relating hyperparameters to objective function and recursively searches for an optimal hyperparameter setting. The program uses methods structurally similar to those undergoing rapid development in image processing in the natural sciences. It has been put into better-documented and more portable form and was used in research for several ph.D. dissertations last year.

In addition to the course instruction and faculty research uses of the microcomputers described above, several of the ATs have been placed in offices housing graduate students. These computers have been used extensively for research by these students, and have prompted efforts that might not have been made had students been restricted to a mainframe-computing environment. Some examples of graduate students' research follow:

Steve Cassou has been using GAUSS to find stable and invertible solutions to general equilibrium models, linearizing around the steady state to find candidate solution paths. It has the potential to be widely used.

Ayse Imrohoroglu uses FORTRAN on the Cray 2 to simulate equilibrium models with liquidity constraints on consumption and debt. She downloads results to the AT and statistically analyzes and plots them there.

Eric Leeper uses RATS on the Cray 2 to backward-solve and simulate a general equilibrium model. He downloads results to the AT and statistically analyzes and plots them there.

Jeong-Wen Chiang has recently been awarded a Ph.D. for his work implementing an extension of Pitt and Lee's research on estimation of demand systems subject to inequality constraints.

As can be seen in many examples above, because versions of RATS, FORTRAN, and C run on many mainframe, mini, and microcomputers, the Woksape project has helped to provide a ''seamless'' computing environment that greatly increases the efficiency of research efforts and may result in consideration of projects that would previously have been rejected as untenable. Graduate-student research now more frequently involves computation, because students have become familiar with the machines earlier in their careers.

Future Plans

Sims is working on an interrelated set of programs to analyze and solve dynamic stochastic optimization models by the ''backsolving method''. When the new software is completed, the solution method may spread more widely and see use as a teaching tool.

We will face a continuing need to update and acquire compiler and numerical-analysis software as the tools available improve. At the point where 80386 machines can run compilers that address large amounts of memory, we will definitely need to install at least some machines of this type. One faculty member who has an 80386 board with an 80387 coprocessor in his own AT has reported that some RATS programs speed up by a factor of 4 or 5 over the same programs on a high-speed AT with 80287 coprocessor. Such speed, together with an ability to use several megabytes of memory efficiently, will substantially shift the point at which problems move from the microcomputer to a mainframe.

Equipment

6 PC/ATs with Enhanced Graphics displays
2 PC/ATs with Professional Graphics displays
1 PC/AT
8 Proprinters

Project Number: CLA07

Graphics for Statistics

Kinley Larntz and John Andersen
Department of Applied Statistics

Purpose

In the past several years, our department has seen the usefulness of the personal computer in the classroom. The presentation of many statistical concepts can be enhanced through the power and speed available with this tool. While many packages exist to carry out statistical analyses on personal computers, however, there are few, if any, worthwhile software packages available for teaching statistical concepts. With the help of Project Woksape, we are creating a collection of programs to meet this need.

Progress

Originally, module programs were written to be used in the laboratory sections of Statistics 3091, 5021, & 5022. These were written in portable FORTRAN 77, most using only character graphics for initial ease of programming and increased portability. Based on feedback from the classroom experience, the structure of the programs was modified, bugs were ironed out, and the programs were rewritten in TURBO PASCAL for IBM hardware.

Graphics is an important tool in the educational process. The original programs, as noted above, were written using character graphics. The new TURBO PASCAL programs all use the graphics capabilities of the IBM PC. Several programs have been written to take advantage of the Enhanced Graphics standard. In addition, all programs have versions that work with the Color Graphics standard.

At this time, we have completed ten modules and used various versions of these programs in courses at the University. Based on student feedback, modifications will be made to several programs. The success of the programs seems to be dependent upon the commitment of the instructor and teaching assistants presenting the programs, more than the individual programs themselves. A list of the completed programs follows:

Completed modules:

1) The Correlation Coefficient
2) Confidence Intervals
3) Sampling and Histograms
4) Normal Probability Plots
5) Least Squares Regression
6) The Law of Large Numbers
7) The Mean and Standard Deviation
8) The Central Limit Theorem
9) Buffon's Needle Problem
10) Combinatorics: The Matching Hat Problem

Software Conversion

We received new equipment in 1988. The number of faculty members participating in the project expanded, and conversion of statistical teaching software available on other computers was started.

Within the past year, we completed two major conversion projects. *Multreg*, a regression analysis program developed at the University of Minnesota, was converted to an IBM version. Also, *MacAnova*, a newer program designed to aid instruction and computation for experimental design, was converted to an IBM version. Both developments greatly aided students taking statistics courses in introductory statistical methods, regression analysis, and experimental design.

Equipment

3 PS/2 Model 60s with VGA displays
2 PS/2 Model 60s with 8514 displays
2 PC/ATs with Enhanced Graphics displays
7 Proprinters
1 Color printer

Project Number: CLA08

Self-Paced Active Learning Language Drills in Russian

Gary R. Jahn and Adele K. Donchenko
Department of Russian and East European Studies

Purpose

A team of developers led by Professor Gary R. Jahn has produced a series of instructional and drill programs for use in computer-assisted teaching of the Russian language at various levels of instruction. The specific objectives of these materials are as follows:

1. to provide interactive presentation and drill of basic vocabulary (in two versions: with and without peripheral audio);
2. to provide interactive instruction and drill of noun, verb, and adjective morphology; and
3. to provide interactive instruction, drill, and reference for basic grammar and syntax.

Progress

We developed a five-program complex to address the first two purposes mentioned above. "Russian Conjugation and Declension" consists of five modules: "Base-Form Vocabulary," "Pronouns," "Nouns," "Verbs," and "Adjectives." A version of "Base-Form Vocabulary" has been adapted to provide students with a facility for reviewing basic grammar structures and required vocabulary simultaneously. The "Nouns" module was successfully adapted to run on the PS/2 under Microsoft Windows.

Design is complete, and implementation is in progress (scheduled completion date is July, 1989) for a program answering the requirements of #3, above. Tentatively called "Sentences," it is a joint project of Professors Jahn and Zahavy (Ancient Near Eastern and Classical Studies). This very complicated program will provide a shell into which various alphabets can be loaded, thus providing a mechanism for the creation of tutorials, interactive grammar drills, and reference materials in and/or about any language.

The purpose of all this software is to liberate the basic language teacher from the mechanical tasks of presenting and drilling vocabulary, morphological change, and basic grammar structures, thereby permitting a reallocation of classroom time to more vital, interesting, and imaginative modes of developing language proficiency. Most of the programs mentioned here have already been extensively used and tested as part of the actual curriculum, both here at the University of Minnesota, and elsewhere.

Support from a number of sources has contributed greatly to the success of this project. Project Woksape, IBM, Project Assist, the Department of Russian and East European Studies, the Summer Session Innovation Fund, the Educational Development Program, the Small Grants Program, and the U.S. Office of Education have all made important contributions to the funding and/or implementation of this project. At a conservative estimate, this project has attracted some 250,000 dollars worth of equipment and monetary support, more than four-fifths of which was generated from sources outside the University of Minnesota.

Our experiences in carrying out this project have been uniformly positive. Virtually all of our original plans have been realized successfully. The resulting software is now in daily educational use and is producing the anticipated benefits, both in terms of superior presentation of rote-memory tasks and in terms of class time being made more productive. The software is innovative, educationally useful, and on the leading edge of computer applications to foreign-language teaching.

Equipment

5 PC/ATs with Enhanced Graphics displays
5 Proprinters
2 Enhanced Graphics displays
1 Streaming tape drive
PC Network

Project Number: CLA09

Simulations and Instructional Programming

Robert Leik, Ronald E. Anderson, and
Craig L. Roberts
Department of Sociology

Purpose

With appropriate computer workstations for developmental work, it is possible to offer students a variety of in-class, hands-on experiences via appropriate simulations and related instructional packages designed to illustrate principles of social organizations and social dynamics, and methods of sociological research. Thus, this project will result in instructional programs whose dynamic graphics capabilities will enhance students' understanding of sociology. The project also includes the development of materials that will offer students practical experience with such research methods as automated interviewing.

Progress

The Department of Sociology, under the leadership of Professors Robert Leik and Ronald Anderson, has been working on several instructional-computing projects supported by Project Woksape. Work accomplished is described below. Professors Leik and Anderson collaborated on the four game simulations (items 1-4) and will continue working on the Simulation Generator (item 5). Professor Anderson has done all development of the use of spreadsheets and graphics (item 6). Professor Leik designed the PICSTAT system (item 7), as well as related statistical-instructional routines. All of the projects received assistance from Craig Roberts. The four simulation games had additional assistance from Gregory Gifford and Andrew Esh, and the PICSTAT system was developed with considerable programming support from James Hove.

1. The Social Power Game. This game simulation, completed in 1987, won the EDUCOM/NCRIPTAL "Distinguished Software" award in that year. The game was designed to teach undergraduates the nature and process of power relationships by role-playing a member of a corporate board of directors. As a result of the award, Professor Leik has been asked to give several presentations around the country, including one with Craig Roberts, which was the opening presentation of a Social Science Day program at IBM headquarters in New York. In part due to extensive use of StoryBoard Plus, provided by Project Woksape, all of these presentations have been very well received.

2. Life Course Simulation. Designed to teach students about the consequences of life choices and how to apply abstract concepts of life-course and family-life realities, this simulation allows students to play out their own lives, starting at age 15 and progressing up to age 90. The simulation emphasizes social linkages, the approval/disapproval of others with whom one is connected, and the implications of those evaluations for future life opportunities or constraints. Several sociology classes have used the simulation as part of the course content, typically requiring that short papers be written linking the simulation experience with more abstract course material. Most of the several-hundred students who have used the simulation have found it both interesting and instructive.

3. Public Opinion Exercis: American Sexual Values. More in the nature of an interesting and intriguing interactive quiz, this program allows the student to estimate how the U.S. population has responded to a variety of questions dealing with several aspects of sexuality. Actual data from national surveys are used as a basis for successive corrections of estimates, until a reasonably close answer is entered. Overall scores are provided for each subsection. Several questions allow informing the student how his/her opinions compare with the broader population.

4. Social Indicators Game. The original format of this simulation game places the student in the role of administrator for a small, self-contained planetary society. A complex of determinate, probabilistic, and random factors affect all aspects of the system, and the administrator (student) has control over taxation and budget-allocation matters. Continuous monitoring is provided via a bank of eight thermometer-like gauges registering economic, social, and health aspects of the system. If the administrator takes no action, the system will inevitably destroy itself. Optimal decisions, on the other hand, allow developing a strong, self-maintaining system. The intent is to teach some principles of system operation within the context of assessing and acting upon indicators of the type that policy makers typically use. A more recent version of the game places the student in the role of a county supervisor, rather than administrator for a hypothetical planet.

5. Simulation Generator. A dynamic system simulator has been under development for some time, but the press of other projects has necessitated delaying completion until the coming year. The program will enable closer linkage between typical social-science causal modeling in the form of structural equations models and the implications of dynamics for such causal systems. Before further progress, however, it will be necessary to shift from an earlier non-graphic approach (originally requested by publishers) to one using powerful, high-resolution graphics.

6. Statistical Analysis Exercises Using Spreadsheets and Graphics. These exercises have been developed and used regularly by Professor Anderson in teaching students how to use computers for a multitude of academic and scientific tasks. Students have learned to use a large data base from the Twin Cities Area Survey in conjunction with such software as STATA, SPSS/PC, PC FILE, and PC CALC. As fully-equipped computer classrooms become more readily available for such courses, this type of instruction will be able to reach a much broader segment of the student population.

7. Picture Statistics and PICSTAT. These programs use the great flexibility of Microsoft Windows to enable either lecturer or student to explore step-by-step computational routines, using color-coded visual links between the data and the computations, for a variety of statistical measures. At all times, the user has immediately available such reference material as short commentaries on the logic of each procedure, a glossary of statistical terms, brief answers to "Assumptions," "Why bother?" and "Where do we go from here?," and some graphic routines for each procedure. Picture Statistics, the first of the programs, has been listed with Wisc-Ware as one of the Woksape Windows projects. It includes Chi-square, Lambda and Gamma, and related measures. PICSTAT has augmented Picture Statistics by adding linear correlation and regression, including such options as graphic scatter-plots of any pair of variables from a predefined data file, color-coding by a third variable, the ability to identify and suppress any data point and, again, step-by-step procedures for calculation of parameters and indexes. The PICSTAT program has been submitted to the third annual (1989) EDUCOM/NCRIPTAL awards competition.

Equipment

1 PS/2 Model 50 with VGA display
10 PC/ATs with 9 Enhanced Graphics displays
11 Proprinters
1 Color plotter

Project Number: CLA10

Computer Assisted Mapping Project

Philip Gersmehl and James Young
Department of Geography

Purpose

A primary objective of the Department of Geography at the University of Minnesota is to prepare students for a world of automated data analysis and information display. Project Woksape provided the funding to address two major goals of this objective: 1) to provide students with the opportunity to learn and compare different computer mapping approaches, and 2) to equip the department's microcomputer lab with the hardware required to run the programs and produce maps.

Progress

The project employed two students. A graduate student was responsible for evaluating ten existing software packages, designing the specifications for a shell program to integrate the mapping packages, and writing the documentation for use of the shell program. A second student was responsible for the actual programming of the interactive shell. The five mapping packages included in the shell allow students to experiment with a wide variety of maps. The shell program provides basic instruction about mapping to inexperienced users; descriptions and data requirements for each map type aid the student in selecting the most appropriate mapping technique. The shell program starts the mapping package once the student makes a selection.

The Department of Geography has, through the past two years, obtained nearly all of the equipment necessary for executing the mapping packages. Students now can design maps using IBM AT micros with EGA and color monitors. Students also have access to digitizers (for creating new boundary files) and a plotter and printers (for producing hardcopies of the maps). It is now possible for geography students to use computers to perform many data-manipulation and map-production operations.

Students who have worked with the mapping packages have expressed a high level of satisfaction with the resulting maps, despite occasional frustrations. The students not only gained experience with a variety of mapping packages and automated data processing, a goal of this project, but also learned about map design and communication. Their improved understanding of maps should make them better geographers.

Several opportunities occurred for classroom presentations during the 1986-87 academic year. Demonstrations of specific software packages were given to the Geographic Information Systems and Computer Cartography classes. The Introductory Cartography class heard a presentation on the general use of PCs for mapping. The graduate research assistant with the project also gave a presentation on PC mapping software to a workshop sponsored by the Metropolitan Planning Commission. A set of slides, illustrating features of the various packages, is available for use during the presentations.

Future Plans

The interactive shell program introduces new users to computer mapping and the commercially available mapping software selected for use by the Department of Geography. A set of printed guides will accompany the shell program, giving simple, step-by-step directions for creating a map with one of the mapping packages. The guides will be useful as part of structured class exercises for students working independently. Students will be able to obtain a package guide, access the mapping package directly or through the shell program, and follow instructions to create the desired map.

Integration of the mapping software into geography classes will take a variety of forms (some already underway). All professors in the department received a summary description of the mapping packages and a survey seeking information about classes that might use computer-mapping exercises. Responses to the survey indicated an interest in developing exercises for a number of classes, including Language of Maps, Cartographic Analysis, and Computer Cartography. The creation of a set of data bases and boundary files will provide a foundation for the exercises.

Many students will learn about and use the mapping packages independent of any course. Maps add clarity and attract attention to written text or oral presentations. The shell program and mapping packages provide guidelines and allow construction of maps by individuals possessing limited experience with traditional cartographic methods, but who wish to include maps in research reports. Program users also can create maps in overhead and slide formats for classroom presentations.

The computer-mapping project has established a solid foundation for automated mapping instruction in the Department of Geography. The interactive shell program and mapping guides provide students with the basic tools for learning about the mapping capabilities of IBM microcomputers. Students and faculty in the department now have the means to produce a variety of maps for classroom and research activities using modern computer technology.

Equipment

3 PC/ATs with Professional Graphics displays
2 Enhanced Graphics displays
3 Proprinters
1 Color printer
PC Network

Project Number: CLA11

Experimentation and Assessment: Computer Networks in Psychology

Department of Psychology

Research funded for this project encompasses several areas of psychology. The eight subprojects that comprise the project are listed below and described in the following pages.

1. Computerized instruction in research methods in social psychology (Mark Snyder and John Fleming)
2. Computerized adaptive testing (David Weiss)
3. Computer-mediated systems of assessment and interpretation (Jo-Ida C. Hansen and Beth Haverkamp)
4. Computer-based vocational classification (Rene V. Dawis)
5. Simulations of group decision-making processes in industrial/organizational systems (Ruth Kanfer and Phil Ackerman)
6. Survey design and analysis in social psychological research and theory: Computer-assisted telephone interviewing (Eugene Borgida)
7. Self-instruction in behavioral analysis (Travis Thompson and Bruce Bakke)
8. A tutorial and remediation system, TUTOR (Paul W. Fox, Department of Psychology, and Archie Wilson, Department of Chemistry)

1. Computerized instruction in research methods in social psychology: Mark Snyder and John Fleming

Purpose

This project concerns computerized instruction in research methods in social psychology, specifically, developing computerized laboratory exercises for Psy 5-206, Research Methods in Social Psychology.

Unlike other universities in the country that offer a laboratory course in social psychology in addition to an upper-division methods course, our Psy 5-206 course has had to serve both purposes. As a result, students have not been able to acquire the kind of direct research experience with experimental and survey methods that typically is associated with such a course. In this project, we will develop sets of computerized exercises that will engage students as researchers in actively and systematically working with data and research designs. For some of these exercises, data will be drawn from classic and contemporary experiments in social psychology. For others, the exercises will focus on the ethics of social research and will involve a set of hypothetical studies that presumably come before the University's Human Subjects Committee. For yet other exercises, students will gain first-hand experience with questionnaire construction, administration, and analysis.

We should also note that, as part of our project, we are planning an evaluation component in which we will systematically compare the academic performance, both short- and long-term, as a result of participating in the research methods course, both with and without the laboratory component.

Progress

At the beginning of the 1987 calendar year, the project had barely begun. Since then, work has progressed significantly. In particular, Professor Fleming has completed preliminary work on four modules of laboratory exercises for a course in social psychology (social cognition and research methods).

Future Plans

Beginning with the 1987-88 academic year, the research methods course will be taught by Professor John Fleming, who will be actively involved in developing these computerized laboratory exercises. We anticipate that some 30 to 50 students per year will enroll in Psy 5-206 and participate in the computerized laboratory exercises developed under this project.

2. Computerized adaptive testing: David Weiss

Purpose

The objective of this project is the implementation of general-purpose software for computerized adaptive testing (CAT) in any departmental course that uses objective examinations. Our initial development efforts are focused on the Psy 1001, Introduction to Psychology, course. This course was selected because of the large number of students (approximately three to four thousand per academic year) in the course from whom we could derive the item statistical information necessary for implementing efficient methods of adaptive testing. This course is also uniquely suited for our initial efforts since it involves filmed lectures, thus allowing the presentation of lecture material to be constant across the last five years for which item-response data are available.

Progress

Item Bank Development. Initial effort in phases two and three of the project was directed at creating a computerized item bank for the Psy 1001 item pool. A design for a computerized item bank that would accommodate growth as the course evolves and changes was decided upon, along with a system for coding the items. Although the computerized item bank has now been 'stocked' with items, management and maintenance of the item bank is a continuing effort. During phase three of the project, we developed software for printing hard copy from the random-access computerized item bank. Software has also been developed to provide the capability of easily printing tests in reproduction-quality form and answer keys, for Psy 1001 course examinations. Automating the test-construction process for Psy 1001 was officially implemented in Spring Quarter, 1987, with great success.

Development of a CAT System. In order to implement CAT, a great deal of information (i.e., data in the form of examinee responses to test items) must be available from the test items that will be used. The process of getting existing machine-readable data from the last five years into usable form has been time-consuming. The first year's worth of data took six months to process.
With improved software, the second took only three weeks. During the next phase of the project, the processing procedures will be further improved, so that the test data are available to us in exactly the format we require for our analyses.

In order to maintain and provide quick access to the statistical and administrative information history for several thousand test items, it was necessary to develop and item statistical database system. During phase two and early phase three we constructed a prototype shell for such a system using the dBase III programming language, but found that the sorting and searching capabilities in that system were much too slow for our requirements. The entire prototype system was reimplemented in Pascal with much greater success. During phase four we hope to complete the full development of this database system "shell".

Also in phase three, a number of software programs were developed to provide state-of-the-art item response theory (IRT) psychometric analysis of the test data. These programs will facilitate the ease of future implementations of computerized adaptive testing by microcomputer.

Future Plans

Once the data for each quarter are transformed into a form usable in the item bank, item parameters must be estimated for each item and those parameters linked onto the common metric to be used in scoring examinees. Each of these aspects of the process -- item parameter estimation and linking -- has technical problems associated with it that have been under investigation. As these problems are resolved, relevant programs will be integrated into the comprehensive data preparation and monitoring system necessary for full implementation of a maximally useful adaptive testing system.

Once enough item-level data have been analyzed and entered into the item-banking system, we can begin developing CAT testing for the course. Initially, this will affect about 200 students per year.

3. Computer-mediated systems of assessment and interpretation: Jo-Ida C. Hansen and Beth Haverkamp

Purpose

The future of computer-based testing for research on basic psychological constructs and traits has been predicted by many psychologists in the past decade. To date, most efforts at computer-mediated assessment of the trait of vocational interests have proceeded through development of new inventories specifically designed to be administered at a computer keyboard. In contrast, little effort has been directed toward converting existing inventories, most notably the Strong Interest Inventory (SVIB-SCII), to computer-administered and/or computer-interpreted formats.

Two large-scale projects were identified as objectives for our agenda in the first phase of the project:

1. Development of computer-mediated systems of assessment and interpretation of the Strong-Campbell Interest Inventory (SVIB-SCII)
2. Development of a computer-accessible bibliography for students engaged in interest-measurement research.

Progress

Significant progress achieved during the project's initial year led to refinement and expansion of further objectives. Continued success in both developing and implementing Woksape software prior to the project's completion has permitted us to begin the necessary testing of the product's reliability, validity, and accessibility to students.

During the first year, we developed a computer-administered version of the Strong Interest Inventory. This system has the potential to be an excellent teaching device in assessment and career-planning courses and to facilitate development of an ongoing data base for evaluation research. During the 1986-87 academic year, approximately 175 students were exposed to software developed through the Department of Psychology's Center for Interest Measurement Research (CIMR) Woksape program. The students have also responded to a questionnaire designed to assess student satisfaction with computerized formats.

Significant progress has also been achieved in development of the computer-accessed bibliography of interest-measurement literature. Over 2000 bibliography entries relevant to interest measurement have been collected and formatted, and a scheme for their integration into an existing bibliography software package with other CIMR data systems has been developed. Approximately 50% of these bibliography entries have been entered into the computer.

Future Plans

In the future, development of a computer-mediated system will facilitate instructional objectives at two curricular levels. First, the system can be implemented as part of the curriculum in freshman-sophomore courses in career planning, such as Psy 1-011 (Career Decision Making) and IT 1-222 (Introduction to Careers in Science and Engineering). Second, a computer-mediated system would provide an excellent teaching device in such graduate-level, counselor-education courses as Psy 8-502 (Counseling II: Assessment) and Psy 8-574 (Seminar: SVIB-SCII).

Another objective focuses on the necessary validation of the computer-administered version of the SVIB-SCII described previously. In the next phase of the project, we will compare results of computerized and traditional forms of test administration and proceed to identify format-specific factors that may facilitate or impede students' understanding of their test results. Final stages of the project will include writing a handbook for student use of the completed interest-measurement data-retrieval system; installing the data base and bibliography-retrieval system on an AT or PS/2 hard disk for convenient student access; and training additional students in the methodology of computerized data retrieval.

4. Computer-based vocational classification: Rene V. Dawis

Purpose

The major goal of this project was to develop a computerized, comprehensive, psychological taxonomy of work to be used in training students. The taxonomy would classify the 20,000+ occupations listed in the Dictionary of Occupational Titles in terms of ability requirements and reinforcer characteristics. At the graduate level, the computerized taxonomy would be used to teach students how to identify the most appropriate career choices for individuals. The computerized taxonomy wouldill also facilitate teaching vocational psychology at the undergraduate level by providing a person-environment-fit model for the study of work. It is a fact that many students do not have much information about occupations, and what information they do have is largely based on social stereotypes.

This project would benefit students in three undergraduate and five graduate psychology courses. In addition to the students who may benefit from using the system in their course work, students seeking career guidance could benefit from the system. Eventually, students who seek career counseling from University Counseling Services, the Career Development Offices, the Academic Advising Offices, and the Extension Counseling Office could be helped by the computerized taxonomy.

Progress

The primary effort prior to January 1, 1987, was to organize the occupational data base and to write the necessary programs for data entry, modification, and retrieval. Occupations in the data base have been organized into units called taxons. Each taxon consists of a group of occupations with identical ability requirements and reinforcer characteristics. The cross-classification of ability requirements and reinforcer characteristics yields a potential 729 taxons, with each taxon representing a unique combination of an ability-requirement pattern and a reinforcer-characteristic pattern.

To date, our data base contains 131 taxons, which include 1769 occupational titles covering a broad spectrum of the world of work. The computerized taxonomy has since been referred to as MOCS III (Minnesota Occupational Classification System). Using software developed with Woksape funding, we were able to produce the data base in hard copy in the form of a reference handbook.

With Woksape programming support, we were able to develop software to access the data base according to a set of rules. With the clerical support, we have been able to gather an additional 2000+ occupations to be included in the existing data base.

Future Plans

Work will continue on expanding the data base and on developing additional softwareto make the program user-friendly, so that it can be used more effectively in the classroom.

5. Simulations of group decision-making processes in industrial/organizational systems: Ruth Kanfer and Phil Ackerman

Purpose

Our original objective was, and remains, the implementation of computerized instructional modules to enhance graduate and undergraduate education in several courses, in particular, those courses concerning ability measurement, performance assessment, the study of individual and work-group decision-making processes, and human-machine systems. Specifically, our efforts have been towards enhancing instruction by providing undergraduate and graduate students with interactive exercises and case problems relevant to the applicaton of I/O and Differential Psychology.

In conjunction with our colleagues, John Campbell and Marvin Dunnette, the courses we targeted for interactive modules are 5-701, 5-702, 5-703, 5-704, and 5-705. Respectively, these course concern Personnel and Industrial Psychology, Psychology of Indiviual Behavior in Organizations, Psychology of Organizational Training and Development, Engineering Psychology, and Work Motivation. In the aggregate, these courses contain well over 400 students per year. Mini instructional modules were proposed for these courses. In some of these modules, students inplement specific theories or models and observe their effects on subsequent individual/organizational variables.

In other modules, students learn the interactions of task characteristics with human information-processing capabilities.

Progress

Two basic instruction/demonstration modules were developed directly through the Woksape grant (the Vigilance task), or were aided by the Woksape grant (the Air Traffic Control Simulation). Descriptions of these programs are presented below:

Vigilance demonstration

An important type of human-machine interactions is known as detection of weak, low-frequency targets (in noise) over an extended period of time. This is typical of a variety of different occupations, including (a) surveillance, (b) industrial quality control, (c) air traffic control, (d) seaboard navigation, (e) power plant operations, (f) jet and space flight, (g) operation of agricultural machinery such as tractors, (h) long-distance driving, and (i) anesthesiology (monitoring patients' life signs).

Human performance in such activities is, however, typically described as rather poor during a work shift, with performance on sustained tasks dropping precipitously after about one half-hour "on-task." That is, while the task can be performed well by the individual, performance over extended periods of time drops in accordance with a well-known function called the "vigilance decrement."

A number of theories have been proposed to account for the vigilance decrement, including "expectancy" and "activation" explanations. The current demonstration provides students with first-hand experience of the vigilance decrement. A second version of this task provides the student with the opportunity to change critical task characteristics such as (a) event frequency, (b) target frequency, and external environmental factors such as illumination and noise stress. These options allow students to vary task components in a way that allows for a hands-on testing of these various theories that attempt to explain the vigilance-decrement phemonenon.

Air Traffic Control: A Simulation Environment for Demonstration of Principles of Motivation, Learning, and Aptitude - Treatment Interactions

The Air Traffic Control (ATC) task is a rule-based, real-time, fully computer-driven simulation environment that includes some of the activities performed by air-traffic controllers. The ATC task provides a test-bed for students in advanced undergraduate, and graduate-level courses in industrial/organizational psychology to experiment with a variety of different empirical/theoretical phenomena. To date, the research and development versions of the simulation environment have been used in demonstration projects that concern (a) the effects of goal-setting on task training effectiveness, (b) the interactive effects of task complexity and motivational determinants of learning, and (c) the effects of knowledge training (declarative vs. procedural part-task training) on skill acquisition. In addition, students have received hands-on demonstrations of practice-based changes in attentional demands during skill acquisition, and the development of automaticity in skills. An upcoming student project concerns the effects of surveillance on performance effectiveness.

In order for the students to investigate how skill requirements interact with student characteristics, the ATC simulation shell is written in a way that the student can change and/or assess a variety of different aspects of the interface. Examples of these parameters include (a) discovery vs. structured learning, (b) manipulation of performance goals and incentives, (c) task complexity and difficulty, (d) speed requirements, (e) review and expert demonstrations, and (f) feedback/knowledge of results.

For review purposes, the interface includes a keystroke recording/playback feature, which allows for classroom demonstrations of strategy development and reactivity to various task parameter changes.

6. Survey design and analysis in social psychological research and theory: Computer-assisted telephone interviewing: Eugene Borgida

Purpose

The original objective of our Woksape project was to create a three-unit network for use in the social-psychology methods courses. Questionnaire design and the analysis of survey data have not been taught previously at either the undergraduate or graduate levels in our department. A survey component for social psychology's 5-level research-methods course will be developed from our project and, thus, Research Methods in Social Psychology will be one of the courses affected by our Woksape efforts. The development of a graduate course on survey design and analysis in social psychology is also planned. Research Methods in Social Psychology has typically enrolled 15 students (we expect to teach the course two or three times a year with an enrollment of 15-20 students per term) and a graduate-level course on survey methods would be expected to draw at least 15 students each time it is offered.

Progress

The focus of our efforts has been and will continue to be the Ci2 interviewing system. This computer-interviewing software package is much more sophisticated than we realized. We will be able to do self-administered interviews, political polling, telephone interviewing, and experiments within telephone surveys using the network in our research methods course. This is in addition to being able to use Ci2 for designing surveys and analyzing and interpreting survey results. We have reviewed the basic documentation for Ci2 and have concluded that the Ci2 tutorial will be an inadequate way of introducing students to the system.

Over the past nine months, our three-unit network has been set up twice, most recently over the summer when it was relocated to another room in the Social Relations Lab. Prior to relocating this summer, we encountered various bugs in setting up the network that have consumed more time than anticipated. Most important, our Ci2 interviewing system is still not functioning satisfactorily in the network, and we have had problems with some non-network software. In addition, because both programmers have served as instructors and consultants to the various research projects that have been using the network to examine the survey data sets on file, they have had less time to devote to the proposed instructional applications. Thus, we need more of their time in the upcoming year to refine and complete the instructional applications and to continue to do general troubleshooting and network maintenance.

Future Plans

Now that our network has been organized, we propose to develop a series of Ci2 workshops during Fall Quarter 1987 and Winter Quarter 2988, to introduce users to the Ci2 system. We will use various questionnaires and survey data sets already on file to illustrate the utility of the Ci2 system. We will also conduct telephone interviews and use the survey data in an on-line demonstration of the interface between Ci2 and SPSS/PC+. The winter-term workshops will coincide with the Research Methods in Social Psychology course and could be used then as the survey lab component of that course. The final set of workshops during the spring quarter will highlight how Ci2 can be used for experimental purposes, either to design and execute experiments within surveys, or in the design and execution of computer-assisted experiments in social psychology.

7. Self-instruction in behavioral analysis: Travis Thompson and Bruce Bakke

Purpose

The goal of this Woksape sub-project is to demonstrate a practical method for instructing undergraduate students in collecting and interpreting observational data on human behavior. An interactive videodisc program will be developed to provide instruction based upon unobtrusively videotaped samples of behavior. The program will be authored with Learning System/1 for presentation on InfoWindow in the Department of Psychology Applications Laboratory.

The interactive videodisc program will serve two major functions: 1) The program will demonstrate that interactive videodisc instruction in behavioral observation can play an important role as a laboratory exercise supplementing traditional text and lecture formats. 2) It will be used a prototype for a revised and enhanced version created for distribution to universities across the country.

Exercises developed for this sub-project will supplement courses in the behavior-analysis sequence, Analysis of Behavior (Psychology 5017), Human Operant Behavior (5019), and Applied Behavior Analysis (5027). For the past two years, total enrollment in these three courses has averaged 65 students per year.

Production of the videodisc for this sub-project will rely primarily on existing video material. All features of Learning System/1 and InfoWindow will be used in the courseware, including graphic overlay, synthesized speech, and student notepad capability. The program will employ Level III interactivity, with complex branching and tailored feedback. Using the student tracking data available with Learning System/1, instructional modules will be revised based on the results from the students who will field test the program each quarter.

The interactive videodisc program developed in this sub-project will also be a prototype for a revised and enhanced second edition program created for distribution to universities across the country. Funding for development of this second interactive videodisc is being sought from the Annenburg/CPB Project of the corporation for Public Broadcasting. This prototype will employ fully developed courseware written for InfoWindow with Learning System/1, but the videodisc will contain only existing video material and will be specific to behavior-analysis courses.

Progress

The most important progress attained in this Woksape sub-project has been the increase in our understanding of the technology that is available to achieve our instructional goals. Our initial plan was to employ computer-assisted instruction modeled after programmed texts and augmented by animated computer graphics and synthesized speech. After considerable research and discussion, we concluded that interactive videodisc provided the optimal technology for delivery of laboratory instruction to behavior analysis students. Subsequent effort has focused on assembling the resources necessary to produce the interactive videodisc program.

In the spring of 1987, Dr. Bakke participated in a five-day workshop on designing Level III interactive videodiscs, led by Rod Daynes (founder of the Nebraska Videodisc Design/Production Group). We have recently identified several sources of videotape that will be suitable for our prototype videodisc program. In addition, Professor Thompson has continued to assemble a collection of slides and other visual materials, many of which will be included as still frames on the videodisc.

Future Plans

Regrettably, progress halted because Learning System/I and an InfoWindow display were not available to the project, and the Annenberg/CPB proposal was not funded.

8. A tutorial and remediation system, TUTOR: Paul W. Fox, Department of Psychology, and Archie Wilson, Department of Chemistry

Purpose

The basic objective of the TUTOR project is to develop a flexible, multi-purpose, computer-assisted instructional system that could supplement classroom instruction in a wide variety of courses. In designing the TUTOR system, we wished to achieve two basic objects: (1) The system must be capable of presenting a wide variety of question items or problems to students, with the item pool easily expanded and modified. (2) The system must provide more feedback than simply indicating that the student is correct or wrong on any given question. Instead, TUTOR must behave more like an instructor or TA working one-on-one with the student, to identify the nature of the student's difficulty and provide a tutorial explanation and suggestions for remediation.

To achieve these objectives, we require learners to indicate their level of confidence in their answers to each question. This allows us to distinguish much better among "lucky guesses", partial knowledge, strongly held but incorrect views (e.g., misconceptions), and clear understanding than would otherwise be possible. We believe that the idea of linking the student's subjective feeling of confidence in his/her answers to objective measures of the adequacy of the answers is a solid idea with great potential. To our knowledge, we are the first to be developing a CAI testing and tutorial system with this component, though our guess is that in the future many systems will move in this direction.

One final objective of the TUTOR project requires explanation. The original system was designed for use in general chemistry courses. The main goal under Woksape support has been to create a testing and diagnostic tutorial system that is essentially domain-independent. To create such a generic system, we have developed a test and feedback authoring system that guides and prompts the instructor at each key step. The instructor must know and write the problems and accompanying tutorials. What TUTOR provides is the basic framework or shell for the material. It also provides a set of interpretive guides to statistical analysis of students' performance files, which will be helpful and usable even by instructors who shy away from statistics.

Progress

Work on the system from November 1986 to the present has focused on creating the tutorial shell noted above. This system is menu-driven and contains a built-in help facility. The system maintains a data bank of questions and their tutorials. An instructor user can enter a new question or edit an existing one. Other database manipulations, such as printing and deleting questions, are now available. The instructor user can also create a test by requesting that a series of questions currently in the item pool be used. For a student to take a test, the test file thus created is used by another piece of software which we call "TUTOR". Thus, for a student to take a tutorial quiz, a disk containing the software TUTOR and the test file is required. TUTOR produces a file that records each student's performance on the test. This file can then be used by another program we've written to perform statistical analysis.

Future Plans

From January 1988 to the present, we have refined the software described above. In particular, we have: (1) added a number of functions to the statistical-analysis program, (2) increased the flexibility with which users may specify and use disk drives, (3) debugged the existing software, and (4) improved instructions in the Help file.

Equipment for all CLA11 projects

1 PS/2 Model 60 with VGA display
1 PS/2 Model 50 with VGA display
9 PC/ATs with Enhanced Graphics displays
15 PC/XTs with Enhanced Graphics displays
5 PCs with Enhanced Graphics displays
14 Proprinters
1 Quietwriter
2 Color plotters
PC Network

Project Number: CLA12

Exploring Minnesota's History and Cultures

Janet D. Spector
Department of Anthropology

Purpose

The primary purpose of this project has been to enhance our study of Minnesota's history and cultural diversity. The initial focus of the project was an interdisciplinary field study and training program that encompassed archaeology, American Indian (Eastern Dakota) studies, ecology, and ethnohistory. This was followed by efforts to better integrate these research data into classroom activities. The project began in the summer of 1986 with the excavation and analysis of the Little Rapids site in Scott County, Minnesota. The site has extensive archaeological remains of pre-colonial Indians, a 19th-century Wahpeton (Dakota) community, a fur trader's encampment, and late-19th/early-20th-century American settlements. Project participants, including faculty and both undergraduate and graduate students, have worked with artifacts and plant and animal remains from the Little Rapids site, comparative data from other Minnesota sites, and complementary ethnographic and historical resources (both oral and written.

Progress

Little Rapids Data Base

Following the 1986 summer field school and excavations at Little Rapids, we created a detailed database file for the more than 5,000 artifacts collected that year and during three years of previous work at the site. Using dBase III Plus, we created over 3,000 individual records providing information about each artifact's identification, accession number, size, color, shape, material of manufacture, and specific horizontal and vertical location within the site.

During the 1986-87 academic year, students registered for two different courses jointly sponsored by the Department of Anthropology and the CLA Honors Program (Anth 3977, 3960/HSem 3060, 3070). These courses were an extension of the previous summer's field study and focused on techniques used for artifact analysis and public interpretation (i.e., museum design and exhibition). Students used the computers to prepare class projects. They created reports and tables derived from the Little Rapids data base and used this information to identify, locate, and map artifact complexes; identify activity areas; and create charts and graphs to illustrate their findings. Similar reports were also used by students as they worked on the experimental design of museum exhibits and other materials intended for a general-public audience.

Minnesota Archaeological Sites

In addition to the data files for the Little Rapids site, we have used Filing Assistant and dBase III Plus to organize and manage another large data set: the University of Minnesota archaeological collection. Students working under the supervision of Professor Elden Johnson (and funded in part by a grant from the Graduate School) have created two important data files that organize information about (a) over 900 different archaeological and ethnographic collections currently housed in the Department of Anthropology's Archaeology Laboratory, and (b) the contents of these individual collections (over 40,000 records). These collections include materials excavated and/or collected throughout the world. Since 1929, information about the items in these collections was hand-written in ledger books and on index cards. We now have more immediate and comparative access to information about each collection, its place of origin, cultural affiliation, site type, and excavation history. As a result, these resources have become more accessible to both student and faculty researchers.

In addition to this collection information, a second data base has now been completed that will yield detailed information about the contents of each collection. More than 40,000 entries provide information about individual artifacts and other archaeological materials from sites excavated by the Department of Anthropology. We can now access these files to provide summary information about sites on a statewide basis. We can also produce summary reports listing the locations of specific classes of artifacts recovered from sites across the state. These files are being used as part of a large research project focusing on a series of sites int he Mille Lacs Lake region. The residents at some of these sites were ancestral to the people who lived at Little Rapids, and this analysis should provide the basis for a long-term comparative study of Minnesota Indian history that has never been possible before. The Mille Lacs project, directed by Professor Elden Johnson, involves undergraduate students, graduate students, and faculty at the University of Minnesota, and staff members and volunteers at the Institute for Minnesota Archaeology. In the future, we hope to make these files similarly available to researchers across the state for teaching and research purposes.

In 1988, with Project Woksape support, we acquired a useful educational software package written by archaeologists at the University of Wisconsin-Madison. The program simulates archaeological excavation and analysis procedures and allows students to manipulate a realistic set of archaeological data without the time-consuming task of actual excavation. Students choose from a number of known sites those they wish to excavate. Once selected, information about the artifacts found at each site as well as environmental data are displayed. The program also has limited analytical capability and will present data in comparative spreadsheet or graphic format. We have since designed several exercises that adapt the software for inclusion in both intermediate and upper-level Department of Anthropology courses; it has been well-received by faculty and students.

Future Plans

Since 1987, both undergraduate and graduate students have continued to use, refine, and expand the various data files in conjunction with other specialized independent research and study projects related to their degree work. Using Quattro, Borland's recent spreadsheet and graphics software, we are also preparing a variety of computer-generated reports, charts, and graphs that summarize information from Little Rapids and will be included in publications. We continue to develop and maintain a bibliographic data base directly related to archaeology of historic sites in Minnesota, including primary and secondary references. Finally, we hope to create data files based on selected historical documents directly related to Little Rapids, including fur-trade records housed in the archives of the Minnesota Historical Society and information contained in various sources on task and activity patterns of Dakota men and women.

The completion of these projects has already enhanced archaeology research and teaching at the University of Minnesota. In the future, we hope to refine our records and make our data accessible to people working at other institutions in this state and throughout the country via electronic networks.

Equipment

1 PC/AT with Enhanced Graphics display
1 PC/XT with Enhanced Graphics display
2 Proprinters

Project Number: CLA13

A Microcumputer-Based Cognitive Simulation Laboratory

Charles R. Fletcher, Paul E. Johnson, Michael Kac
Center for Research in Learning, Perception and Cognition

Purpose

This project involves the development of a microcomputer-based cognitive simulation laboratory to be housed in the Center for Research in Learning, Perception and Cognition at the University of Minnesota. Our hope is that this laboratory will eventually meet the instructional needs of several departments within the University where the techniques of artificial intelligence are used to model human cognition. In order to provide students with instruction in these techniques we are developing: (1) a set of software tools for implementing cognitive models, (2) several sample programs that use those tools to model human memory, problem solving and language understanding, (3) a series of on-line tutorials that introduce students to our development tools and models. The long-term goal of this project is to provide sixty or more students with ''hands-on'' experience in cognitive modeling each year.

Progress

During the first year of the project, we have focused our efforts on three important areas of cognitive simulation: production systems, connectionist models, and computational linguistics. Progress made in each of these areas is described below:

1. Production systems are one of the two formalisms most commonly used in cognitive modeling. A production system consists of two parts, a set of production rules and an interpreter. Each rule has two parts, a set of conditions and a set of actions. The interpreter examines the rules' conditions and, when it finds one whose conditions are all true, it executes that rule's actions. The latter process usually results in some other rule's conditions becoming true. These models are commonly used for modeling the flow of ideas through a person's awareness as he or she reads, solves a problem, or performs some other complex cognitive task. During the last year we have implemented a simple production-system interpreter, as well as a set of production rules that implement a theory of the processes that occur when someone reads a story and then tries to remember it. The model is relatively simple, yet its performance is quite human. When we compare the performance of the model with a sample of human readers, we find a correlation of .63 in the ideas they recall. We are now working on a set of exercises that will require students to build the production system interpreter, use it to run the text comprehension and recall model, then make some formal comparisons between the model and some human data they will be required to gather.

2. Connectionist models are the other formalism used most often to model human cognition. A connectionist model consists of a collection of simple processing units where each unit represents some hypothesis. For

example one unit might represent the concept "dog" and another might represent the letter "d". Each processing unit has an activation level associated with it that represents the system's certainty in the hypothesis represented by the unit. These processing units are bound together by excitatory and inhibitory connections. Units representing compatible hypotheses (like "d" and "dog" which tend to co-occur) excite one another, i.e. when one becomes active it will raise the other's level of activation. Units representing incompatible hypotheses (like "n" and "dog") inhibit one another. These models process information by spreading excitation and inhibition until a stable configuration is reached where all processing units are either at maximum or minimum activation. This process can be used to recognize objects or to retrieve information from "memory". To date we have implemented several connectionist networks. We have also created a set of excercises that lead students step-by-step through the process of creating such a model. These exercises were used last year in a seminar on cognitive modeling offered by the Psychology Department.

3. Computational linguistics is a branch of linguistics that uses the methods of artificial intelligence for a variety of tasks such as analyzing the syntactic structure of sentences, testing grammars, summarizing texts, translation, and analyzing style. We have been developing materials for a course on computational linguistics. These materials include a tutorial introduction to LISP (designed specifically for linguists) and a set of laboratory projects. The intent is to ultimately have, by Winter 1988, a set of four projects so organized that students without prior knowledge of LISP would do the first three while others would do the second, third and fourth. The first three are now complete.

Future Plans

During the next year we will concentrate our efforts in two areas. The first of these is testing and modifying laboratory exercises. The other is beginning to develope on-line tutorials that introduce students to the software tools we have already completed and lead them through the laboratory exercises and projects.

Equipment

3 PC/ATs with Enhanced Graphics displays
1 PS/2 Model 60 with VGA and display
4 Proprinters
1 PC Network

Project Number: CLA14

Computerized Instructional Materials for Languages Employing the Arabic Script

M.A.R. Barker
Department of South and Southwest
Asian Studies

This project has been terminated.

Project Number: CLA15

The Development of Listening Comprehension in German With IBM PC/AT, InfoWindow and Laserdisk Video

Ray Wakefield
Department of German

Purpose

The goal of this project is the development of listening comprehension in German for college-level students. The means to this goal involve the integration of an IBM-AT, InfoWindow, and laserdisc video to manage and deliver German listening-viewing segments.

The strategy begins with the development of an expert system that collects data on student interaction with a German listening-viewing segment and then selects the listening-viewing lesson with the next most appropriate level of difficulty. The strategy proceeds with the development of an appropriate lesson shell to organize student instruction with each listening-viewing segment: the preview, the segment itself, and the exercises. Each segment is played three times. After each run-through, students enter an immediate recall protocol. Three levels of clues for assistance are available for each spoken sentence during the second playing. The exercises assess student comprehension of facts, as well as interpretive and structural aspects of student responses. The lesson shell maintains cumulative performance data and provides students performance information as they proceed from segment to segment in the instructional program.

The course is based on research on the development of listening competence in a second language that requires students to process spoken-viewed material in the target language. Translation is avoided as an active listening strategy. The course also takes into account research indicating the "naturalness" of visual support for the processing of spoken language, e.g., face-to-face conversation.

Progress

During Winter and Spring Quarters of 1987, we developed a proto-lesson using an IBM PC/AT, InfoWindow, and Pioneer LD-V6000 videodisc player. On June 23, Kim Pearson, Al Becker and I were able to demonstrate a proto-lesson for deans of graduate schools of education at an IBM seminar in Athens, Georgia. Professor James Lee has invited us to give two demonstrations and a presentation at the regional AEP conference in Madison, October 2-6, 1987.

In the summer of 1987, we hooked up a new Pioneer LD-V6000A (the 6000 is out of production) with an upgraded InfoWindow and completed our piloting with 15-20 individual German students. The students were enrolled in second, third, fourth, or fifth quarter German instruction at the time they viewed the proto-lesson. Jason Earle of Project Assist observed each student and noted all problems and comments.

Future Plans

During Fall Quarter, 1987, we will incorporate data from the summer piloting into the design of the lesson shell. This process of piloting, feedback, and revision of 3-4 lessons will continue during the 1987-88 academic year. During the 1988-89 academic year, we will integrate the lessons into the curriculum for one or two multi-section German classes.

Equipment

3 PS/2 Model 50s with InfoWindow displays
1 PC/AT with InfoWindow display
1 Proprinter

Project Number: CLA16

Cartographic Color Analysis and Display

Philip M. Voxland
Social Science Research Facilities Center
Mei-Ling Hsu
Department of Geography

In the past, the cost of high-precision color graphics has forced cartography instructors to use low-resolution displays. New high-resolution, large-format color displays enable student access to higher mapping technology, and new microprocessor technology makes it possible to develop computer-mapping displays from actual data sets. The investigators intend to develop systems that permit computers to be used for experimentation with design and color aspects of thematic maps. Prototypical software will be developed for classroom implementations of color mapping software for computer cartography. Inasmuch as the equipment required for beginning the project has not yet been delivered, it has not been possible to do any substantial work on this project.

In traditional cartography, a wide range of color hues and intensities is manipulated to create a map design that is attractive, versatile, and effective in conveying geographic concepts and information. This is what we also propose to do through computer cartography, except that we believe it is possible to accomplish traditional tasks more rapidly and with better quality. We mean better in the sense that data can be analyzed and classed in different ways, and a much larger number of simultaneous color shades can be employed. The opportunity for students to innovatively experiment with color in design may be greatly increased.

An inherent problem in treating geographic data is the transformation of information from one form into another. Spatial data may be stored as gridded cells, based on parcels of land or satellite images; or they may be organized as a sequence of boundary lines, such as property descriptions or political area boundaries. To make a map, data in one form often must be converted into the other. Throughout any of these conversions, information will be lost, but the loss should be minized so that the final color display faithfully represents the mapping variables in every region of the map. These transformations require substantial computing time and storage.

Initial work will concentrate on creating general-purpose geographic area shading routines for the high-resolution graphics display. Our work will concentrate on creating new procedures for the display and transforming area data. Prototype programs that augment existing commercial packages will evolve from this proposal. These prototypes will make it possible for cartography students and researchers to experiment with color as a design variable for data sets from a variety of sources. The experimental methods will allow shading with discrete categories and ''n-class'' shading.

Equipment

2 PS/2 Model 80s with 8514 displays
2 Proprinters

Project Number: CLA17

CBI for Teaching Grammatical Concepts in Spanish

Carol Klee
Department of Spanish and Portuguese

Purpose

With the adoption of degree requirements at the University of Minnesota that are proficiency-based, students must be able to demonstrate that they can meet defined criteria for listening, speaking, reading, and writing in foreign languages. These are complex skills that require a great deal of classroom time to acquire. Unfortunately, instruction and drill in grammatical concepts require significant classroom time. To make matters worse, this classroom time is largely wasted for most students, since their instructional needs vary greatly and cannot be met efficiently in a lecture or large-group format. Courseware developed through this project is an important step toward meeting the needs of University of Minnesota students in acquiring language proficiency.

Currently, a certain amount of class time that could be used to develop the complex skills necessary to demonstrate proficiency in communication must instead be used to instruct students in grammatical concepts. The teaching of these concepts via computer-based instruction will thus solve two problems: the instructor's class time can be more fully used for the development of communication skills, and instruction on grammatical concepts will be accomplished efficiently and in a way that will guarantee mastery. It is estimated that approximately 2000 students could use this courseware each year, given unlimited access to the necessary computer hardware.

Progress

During the 87-88 and 88-89 academic years, we completed the following activities:

1. The grammatical concept of the Spanish past tense, i.e., the distinction between the preterite and the imperfect, was analyzed for its component attributes.
2. Instructional texts and examples weredeveloped for each attribute.
3. Remedial text and examples were developed for each attribute.
4. A pool of exercises was developed for each attribute.
5. A pilot version of the program was designed.
6. Program design was completed with help from Project Assist.

Future Plans

Final revisions are currently being made on the pilot version of this project, and it will be ready to pilot test with students from SPAN 1103 and SPAN 1104 during the first summer session. Revisions based on our experience with the pilot version will be completed by the end of summer, and the program should be available for student use in the fall of 1989.

Equipment

1 PS/2 Model 50 with VGA display
1 Proprinter

Project Number: CLA18

Isopleth Mapping Incorporating Expert Opinion

William J. Craig
Center for Urban and Regional Affairs

While isopleth mapping is a standard cartographic technique, no successful computerized system exists. The need for such a system is great because of the tedious computations required to interpolate values between reading stations and to locate the placement of lines of equal value (e.g., rainfall, income levels). Many useful algorithms exist to produce effective interpolation results, but they always yield inadequate results. The cartographer or researcher can usually point to areas where the algorithms, operating correctly within their limits, ignored key factors and placed lines on the wrong side of the river, etc. The solution lies in allowing the cartographer's expert knowledge of the geographic area to override the algorithms interactively. This is the ideal world for microcomputers with graphic capabilities. Investigators in this project will develop software that allows the cartographer/researcher to use a mouse to move data points where appropriate and insert pseudo-data points to tie isolines. Using the new data points, the algorithms can be run again to yield a "correct" surface. This technique will prove useful to a large number of students and researchers within the University. Moreover, the demand is high outside the academic setting; the distributor of the most popular and powerful mapping package for IBM microcomputers, AtlasAMP, has expressed strong interest in our efforts to develop this isopleth technique.

Equipment

1 PS/2 Model 80 with 8514 display
1 4216 Personal Pageprinter
1 Proprinter

Project Number: CLA19

Interactive Videodisc Computer System for the Study of Art History

Virginia Larson
Department of Art History

Purpose

The study of art history requires a combined knowledge of images and information. The objective of our Woksape project is to develop an innovative method for students to study art history through the use of a computer and videodisc. This will allow them access to a wide variety of images and data simultaneously. Traditionally, students study art history through the use of lecture notes, textbooks, and supplemental slide reviews, and most of this material is usually presented in a monographic manner. By viewing two monitors, one containing an image and the other containing corresponding data, the student can initiate a self-paced study program. This new technology will provide students with a means to conduct in-depth searches of visual material and encourage them to compare and relate images in ways fundamental to the study of art history.

A particular art history course -- Survey of 19th- and 20th-century Art (ArtH 3012) -- has been chosen for this pilot project, to test both technology and procedural methods, as well as to develop a model for large-scale application. One thousand to 1,500 images will be selected from the Department of Art History Slide Library, and will include all images found in the primary texts for the course, plus many supplemental images shown in class. These images will be stored on a laserdisc, while supporting information will be stored in a data base linked to the disk.

The creation of this image and data bank will provide an invaluable resource tool for students to use on an individual basis for study and research. It will enhance access to visual material by enabling large numbers of images to be easily correlated, thus allowing students to contrast and compare images, trace developments, and synthesize information. For example, students could search for images based upon thematic or chronological approaches. It will be possible to search across countries, artists, and time periods to study a particular treatment of such subjects as ware, family, rural life, portraiture, or the nude. The search for imagery could also be more specific, concentrating on portraits of German children, French nude females, or English families. Searches could be conducted by date -- landscape painting from 1850 through 1870 -- or by artist in a particular medium: the painting, sculpture, drawings, and prints of Degas, for example. Conversely, the range of work produced in a particular medium could be studied as well: drawings from the nineteenth century could be assembled for comparative purposes.

Progress

Start-up time for the project has taken longer than we anticipated, due in part to the complexity of reports and procedures required for the computer program, but primarily to reductions and changes in staffing. Since June 1988, all three members of the Slide Library involved in the project have been employed at 100% time for only six weeks. In December, one of our staff members resigned, leaving the Slide

Library short-staffed for 1-1/2 months and thus burdening the remaining staff with additional responsibilities. With the hiring of a person to fill this position at 80%time, we have resumed work on the project.

The computer development company working with us on the project has a good understanding of the features and expectations of the program, and they expect their work on the project can be completed by the fall of this year. We in the Slide Library are currently in the process of developing the structure of the data base, establishing fields, field lengths, and keyword fields by which images will be accessed. We are also in the process of compiling a list of 1,500 images for the laserdisc. We have set up a small data base for the purpose of collating images from the primary texts used for the 19th-century survey course. Several hundred new images for artists in the period from David to Gauguin have been added to the slide collection in preparation for the laserdisc, but additional images are still necessary. We now anticipate this planning phase for the project to be completed by mid-June and expect to complete the project by the end of fall quarter.

Future Plans

This pilot project will see development of the first workstation of this type at the University of Minnesota for self-paced study of the visual arts and will have an impact on the education of approximately 500 students annually. If the project is as successful as we anticipate, we hope to be able to expand the project to other courses and areas of the collection, thus enlarging the scope of image and information searches. One such possibility would be the Introduction to Art History (ArtH 1002), which could have an impact on the education of approximately 400 students each year.

Equipment

1 PS/2 Model 50 with VGA display
1 PS/2 Model 60 with monochrome display
1 4216 Personal Pageprinter
1 Streaming Tape Drive
1 InfoWindow Display

Project Number: CLA20

Forecasting with Econometric and Markov Process Models

Christina M.L. Kelton
Department of Economics

Purpose

In Fall Quarter 1988, we introduced a new 3xxx-level econometrics course (Economics 3231). This course stresses computation, interpretation, and specific economic applications. The primary statistical tool is regression analysis. We would like forecasting to be a major focus for the course, since some of our economics majors in future careers may be asked to analyze data and make predictions for their firms or institutions. Our main purpose is to develop software (using FORTRAN) to obtain point estimates of regression coefficients and to obtain point and interval forecasts of variables of interest. The forecasts might be for future time periods given forecasted values of explanatory variables, or be outcomes of sensitivity studies for which government policy variables (e.g., spending and taxes) take on alternative values. A secondary purpose is to develop software (again, using FORTRAN) for prediction with nonstandard econometric models (such as Markov process models) to which we feel that students should be exposed.

Progress

To date, we have completed software development for the ordinary-least-squares (OLS) model, appropriate econometrically under certain specific model-linearity and error-term assumptions. Our program called OLS reads from an external data file created by the student, computes descriptive statistics for all variables, and calculates coefficient estimates and accompanying standard errors. Other statistics common to the output of prepackaged regression software (such as R2 and the Durbin-Watson statistic) are computed as well. The student is asked interactively by the software whether he or she would like to make a forecast. If so, after being supplied by the student with independent variable estimates, the software computes point and interval forecasts of the dependent variable, at three different levels of significance (90%, 95%, 99%).

We have also completed software development for a regression model characterized by first-order serial correlation, which may be indicated by the value of the Durbin-Watson statistic. Our generalized-least-squares program called GLS transforms the student's data, by a two-step procedure that first calculates an estimate of the degree of serial correlation and transforms all variable vectors using this estimate. Then, the ordinary-least-squares procedure is invoked with the transformed data as input; resulting coefficient estimates and accompanying standard errors then maintain their desirable statistical properties as for the OLS model. We are currently writing the software to allow the student to make point and interval forecasts, which are not computed in as straightforward a manner as they are in the absence of autocorrelation.

Future Plans

We will now develop software for estimation of multi-equation models, starting with a simultaneous-equations model with a "well-behaved" error-term structure (in particular, no cross-equation correlation). We will program the standard two-stage least-squares-estimation procedure, and cause the student's output to report coefficient estimates and relevant accompanying statistics. We will then extend the software to provide point forecasts or predictions given forecasted values of independent variables, and starting values for endogenous variables.

We will expose students to Monte Carlo simulation methods in developing interval forecasts. We will write software for a multiplicative congruential random-number generator; then for an algorithm to transform the uniformly distributed random variables into normally distributed random variates; then for selecting error terms from a multivariate normal distribution with vector-mean 0, once for each replication of the simulation experiment. In this manner, one can estimate empirical confidence intervals around the deterministic forecasts. Not only will students be able to make predictions where statistical error is explicitly acknowledged, but they will be working in a concrete fashion with the important concepts of probability and probability distributions.

We also plan to work on the nontraditional modeling component of the project. First, we will adapt quadratic programming software for the PC to produce estimates of stationary Markov chain parameters from aggregate frequency-type data, often the only type of data available for socioeconomic applications. Then, we will write software that will allow predictions into the future of distributional shares of entities. We also envision the possibility of adapting as well a nonlinear programming algorithm for the PC, which will allow estimation of nonstationary Markov process parameters.

Our goal is to make available all software to the 3231 instructor, teaching assistant, and students by Fall Quarter, 1989.

Equipment

1 PS/2 Model 50 with VGA display

School of Dentistry

Project Woksape in the School of Dentistry

Michael D. Peterson, Program Director, Clinical Computing Systems

Dr. Rekow's 3-D imaging project, as described in subsequent pages, is the first and, presently, the only Project Woksape-funded activity in the School of Dentistry. It is, however, a very important activity in two special ways. First, it is extremely significant to the scientific community. The work being done applies the new technologies of computer graphics, CAD/CAM, AI, and more to a field of science that integrates the disciplines of dentistry, medicine, and biomedical engineering. Dr. Rekow is gaining international attention regarding her work, because of the obvious impact it will have on the practice of dentistry. In addition to Project Woksape funding, Dr. Rekow has support from NIDR, NSF, BRSG, and others.

The second reason Dr. Rekow's project is important to the School of Dentistry is for educational purposes. Her work is providing a tool never before available to students, teaching faculty, and researchers. As the practice of dentistry changes, so must the methods by which we train the professionals of the future. Computer-aided learning and knowledge of computers have not only become an expected part of a professional's education, but are essential to that process. Projects such as this serve as inspiration to others that our goals and expectations are attainable.

Much has been said lately about the future of dentistry, especially the role of the University of Minnesota in that scenario. Dentistry, indeed, has a future, but it is destined to be, and should be, different than at present, thanks to efforts such as Dr. Rekow's. As the School of Dentistry moves into the implementation of its new strategic plan, it will directly address the expanding role of computers, especially with regard to educational computing. We are grateful for the support provided by Project Woksape and hope that projects like this will grow and prosper and provide a catalytic action to bring the initiatives of our strategic plan to fruition.

Project Number: DEN01

Dental Applications of Three-Dimensional Imaging

Dianne E. Rekow
Department of Orthodontics

Purpose

The major purpose of this activity is to enhance the understanding of three-dimensional information relating to dentistry. Dental clinicians presently operate in a three-dimensional field, yet the major portion of their treatment planning is done from two-dimensional data (like photographs and x-rays). With new technologies, we are developing a system to automate production of dental prostheses, capitalizing on recent advances in CAD/CAM. The objectives of these activities are to (1) enhance understanding of three-dimensional surfaces and motion by using computer graphics to display the surfaces and envelopes of motion, (2) enhance understanding by superimposing surfaces and the envelopes of motion to investigate changes related to alternative treatment options, and (3) enhance education by permitting simulation of treatment outcomes with the computer. Funding for personnel has been provided not only by Project Woksape, but also by the Department of Orthodontics, UROP, and various other sources.

Progress

The system was installed in late March of this year. The Micro CADAM program and mouse were not available until July. As expected, early efforts were directed toward installing the software and learning the system.

Work to date on the study of jaw motion has been most significant. An especially user friendly set of programs is under development for the IBM system. The programs can process raw data, capturing motion of the jaw of a patient as he speaks, chews, and swallows; analyzing the motion; showing relative motion of the lower to upper jaws and one tooth to any other; and displaying the envelope of the motion. The entire process is in color, is menu-driven, and can be operated with ease by an orthodontic resident with no previous computer training. Approximately 90 percent of the work on this project is completed.

Work to date on the study of facial form has not progressed as well as projected. The difficulty is related to a change in digitizer used to recover the data from film. Much of the time since inception of the project has been devoted to solving that problem. The problem was further complicated by an unavoidable change in personnel, and the implicit learning curve required to transfer information and learn the new system. Work is projected to continue on this project for at least an additional year.

Work on the automated prosthesis system continues. Micro CADAM has been installed on the system and some attention has been focused on learning that system and determining if it has sufficient capacity to fulfill the needs for prosthesis design. Additionally, a dental student has investigated the feasibility of using artificial intelligence to model tooth-to-tooth relationships. The selected program, Prolog, permits the user to to identify tooth-to-tooth contacts during a number of alternative motions. Work on this aspect of the project is approximately 85 percent complete. Enhancements will focus on incorporating color and graphics. This is an integral part of the prosthesis system design that will provide an excellent tool for teaching occlusal schemes to dental students, a critical part of their training.

We also had the opportunity to have a visiting expert in the department for two weeks. A programmer who is now a consultant to industry opted to spend a two-week research expedition with us. During his stay, attention focused around exploring some of the options available by using Micro CADAM more fully, adding some enhancements to the Prolog work, and installing Movie.BYU.

In summary, then, some very exciting work has already been done with the aid of Project Woksape funds. More appears as we become more adept at using the system. The advances it has permitted have significantly enhanced our activities. We continually have people waiting to use the system, which has found a vocal, enthusiastic group of users, including researchers, residents, and clinicians.

Future Plans

As we develop software, we continue to discover new options for its use. The most obvious example is the use of the Prolog-based program as a teaching aid for dental students in their occlusion classes. That work, as well as continuing work on the analysis of jaw motion and development of the automated-prosthesis system, will continue with funding from various non-Woksape sources. For the analysis of jaw motion, a series of patients has already been filmed and will be analyzed. In this next year, the software will be available for use by the orthodontic residents and will form the basis for at least one MS thesis, as well as related technical papers. Work on the automated-prosthesis system will continue and within the next year, a crown completely designed by the computer to fit the unique requirements of a patient will become a reality. Eventually, the intention is to install all of the required software for the system on IBM equipment.

Woksape funds have been requested to support continued development of the facial-form-analysis system. Efforts will focus on creating three-dimensional forms of the face that can be viewed from different positions. Additionally, superimpositions of faces obtained from different patients, or from pre- and post-treatment of patients, will be added so changes can be studied. Then, attention can be directed toward creating programs that simulate treatment (or growth) outcomes.

Equipment

2 PC/ATs
2 Monochrome displays
1 Professional Graphics display
1 Proprinter

College of Education

Impact of Project Woksape on the College of Education

Carol A. Carrier, Assistant Dean

College of Education research supported by Project Woksape is directly supportive of the mission of the College, which is "to advance knowledge in the field of education, to prepare personnel for educational purposes, and to provide leadership to educational agencies." Such a broad statement of purpose involves the use of a wide range of media for both research and teaching. In research, technologies (particularly microcomputers) are increasingly useful in broadening the scope of research projects. In teaching, a range of media is needed, both to teach the subject matter relevant to the college's mission, and to demonstrate to students ways in which technology can effectively be used to teach others.

The six projects currently underway and summarized briefly below are in line with the mission of the College of Education and should have impact at both the undergraduate and graduate levels.

ED01: The College of Education offers the only Ph.D. in educational administration in Minnesota. Faculty members in this program work with individuals from throughout the state, which suggests that software developed through this project will receive extensive exposure. A new course in educational administration has been developed; it uses IBM computers in the classroom. In addition, systems flow charts have been created, and school sites have been analyzed for their reporting requirements. Several specialized data bases have been adapted to run on the IBM PC/AT.

ED03: Software that teaches business financial concepts has been developed and pilot tested with undergraduate business majors, inservice teachers, and business teachers attending professional conferences. Further testing of both Lotus 1-2-3 drill templates and a Pascal tutorial will continue. A quasi-experiment will be run to determine the effects of teaching with these materials versus the use of more traditional approaches.

ED04: Significant progress has been made on the development and testing of computer-based materials to teach reading in a second language. A student manual has been written, a new module created, modifications have been made to the basic program, and many other features have been added.

ED05: Software development focusing on the analysis of research problems in child psychology is underway. For example, an application that is designed to administer experiments examining infants' preference for synchrony in visual and auditory stimuli has been developed. These investigators are working on at least three other applications and will incorporate them into a new graduate journal of microcomputer technology.

ED06: A computerized observational assessment system has been created that will help teachers of mildly handicapped students be more responsive to the needs of such students and improve research on these students. A paper-and-pencil version of this system has been used extensively in research, so the method is well-validated. This system is now being tested in three school districts, and further refinements will result from that process.

ED07: This project has produced a Level III interactive videodisc that contains vocabulary words presented in isolation and in a signed-sentence format. This videodisc will be used as the basis for lessons in ASL, six of which are to be created during the next year.

Project Number: ED01

Microcomputers for Management and Decision Making

Charles H. Sederberg and Vernon L. Hendrix
Department of Educational Policy and Administraction

Purpose

SAIS -- The emerging information science is changing educational administration. Most school administration information-system (SAIS) development has occurred outside of higher education, in large school districts, regional data-processing centers, and state-level information systems. Developments 1) have been application oriented, 2) are loosely coupled to information-system concepts and theory, and 3) are seldom reported in journal literature. The goals of this SAIS project are to 1) develop a model of school administration information systems, adapting the concepts of management information systems (MIS) as defined by Gordon B. Davis and decision support systems (DSS) as defined and classified by Stephen Alter, to elementary/secondary school organizations; 2) put into operation a simulated SAIS using the IBM PC/AT; and 3) use the simulated SAIS to support instruction in the educational administration program.

Survey Data base -- In related work, we are developing an IBM PC-AT-based system that will assist educational administrators in surveying various constituencies to evaluate current educational programs and recommend changes.

Progress

SAIS -- Progress to date includes the following:

1. A Social Values/Policy Expectations/School Services paradigm has been developed to distinguish between the information-processing environments of the public and private sectors.

2. The education statutory code and regulations of the State Board of Education have been analyzed to identify policy expectations as a basis for establishing functional subsystems as defined in the Davis MIS model.

3. School Accountant, School Paymaster, Student Daily Attendance, Student Mark Reporting, and Student Record Programs developed by Minnesota Education Computing Corporation (MECC) to run on the IBM PC-AT have been purchased to be used as specialized data bases/applications in the SAIS.

4. Framework by Ashton-Tate has been purchased to run decision-support systems for elementary/secondary school organizations.

5. First drafts of system flow chart models for 1) business and finance, 2) staff personnel, and 3) student personnel functional subsystems have been prepared.

6. Site visits to selected school districts, a regional computer center (TIES), and the State Department of Education have been made to validate flow charts, identify decision-support systems, and determine reporting requirements.

The major problems in SAIS progress are competition for time and problems associated with imposing a rational structure on what is essentially a political and social system.

Survey Data Base -- In the constituent-survey project, preliminary design and coding is complete for the PC-AT-based system that will 1) maintain an item base of various indicators such as constituent group, education objects, and curricular program areas; 2) allow for the selection of items to be placed in questionnaires; and 3) allow the user to specify characteristics of the population and determine the effects of potential sampling strategies (stratified, cluster, sequential, etc., and various combinations of strategies). Finally, the system of programs will perform appropriate statistical analysis on the samples, print summary statistics, and allow for comparisons to be made among different populations after identifying items common to the selected populations.

Future Plans

SAIS -- Work in the areas described above will continue. In addition, there has been a significant change in approach of the SAIS project. Originally, the intent was to use actual school-district data. The SAIS is now focused on developing Independent Practice District #1, Simulation, Minnesota. Two reasons for the change were potential violation of data privacy (FERPA and MGDPA) and the large amount of transaction data involved in actual district operations, which tended to obscure information-system models and procedures that represented instructional objectives.

Survey Data Base -- This system has been used primarily in batch mode on a trial basis. Further programming will move it toward a completely menu-driven, interactive system that can also be used for instructional purposes.

Equipment

2 PC/ATs with Enhanced Graphics displays
9 PCs with Enhanced Graphics displays
3 Proprinters

Project Number: ED02

An Expert System for the Development of Computer-Based Instruction

Stanley R. Trollip
Department of Curriculum and Instruction

This project has been terminated.

Project Number: ED03

Development of Software to Teach Financial Concepts in Business Education

Judith J. Lambrecht
Business and Marketing Education

Purpose

Numerous business-application software programs are available for use as tools in solving information organization, analysis, and reporting problems: data bases, business graphics, spreadsheets, telecommunications, and word processing. Those applications which facilitate quantitative analysis (data bases, spreadsheets, and graphics) are helpful when the user understands the financial-analysis concept being applied. Productive use and appreciation of the programs' capabilities requires knowledge of the business concepts and procedures that can be enhanced through computer use. For example, quantitative business analysis using a spreadsheet requires a knowledge of the analysis process, such as present value of investments or break-even analysis, without the spreadsheet.

While a knowledge of business-financial analysis concepts is necessary to make full, productive use of spreadsheet, database, and graphic applications software, this software can also be used to teach the necessary financial concepts. The effects of key variables in an analysis problem can be given dramatic illustration through the use of the computer, if instructional materials are available to integrate applications software into financial-analysis instruction.

The objectives of this project were to develop and evaluate computer-based instructional software for teaching selected business financial concepts needed to effectively use spreadsheet, database, and graphics applications software. The instructional software was designed for simultaneous use with the application software that illustrates or uses the financial concept.

Progress

We have developed software to teach business financial concepts related to the time-value of money. The current study audience is business education undergraduates at the University of Minnesota. The software and financial problems thus far developed are at the first level of the instructional hierarchy described in the original proposal: The problems do not require extensive student knowledge of spreadsheet operation. Tutorial software has been written in Pascal and is accompanied by drill software written using the macro capabilities of Lotus 1-2-3. The problems do not teach the use of spreadsheets; rather, the instructional objectives focus on business financial concepts which benefit from the rapid recalculation capabilities of a spreadsheet.

Because progress through September 1987 is contained in earlier reports, the following timeline covers progress during the 1986-87 and 1987-88 academic years.

September 1986-January 1987. The first phase of the project was concerned with identification of appropriate student groups for pilot testing and evaluating the instructional software. Pilot testing of spreadsheet templates and instructional lessons began in Fall Quarter, 1986. These materials were used in the accounting teaching-methods class offered during Fall Quarter, 1986. This pilot testing was facilitated by the acquisition of ten additional IBM PC/XT 286 computers.

The Lotus 1-2-3 financial drill templates were demonstrated to business teachers in conference settings at Michigan State University, Lansing, Michigan. Critique received from this group will affect the program's design.

January-June 1987. We revised instructional materials in accordance with formative evaluation results. Materials developed were pilot tested with undergraduate business education students in the spreadsheet applications course scheduled for Winter Quarter, 1987. Development and revision of instructional software continued. In addition to pilot testing with classes of undergraduate students, in-service business teachers in a Trends and Issues class also viewed portions of the Lotus 1-2-3 drill templates and provided some feedback about the ease of use of these materials. Pascal tutorial materials were completed to teach introductory financial concepts related to the time-value of money.

Instructional materials were tested and revised through pilot testing with undergraduate business education students enrolled in an office education course offered during Spring Quarter, 1987.

Summer 1987. Revisions were made in the Lotus 1-2-3 financial drill templates to incorporate:

1) An option for the student to choose any one of 8 types of financial problems related to the time-value of money. Text files of questions of each type and accompanying keys were prepared.

2) An option for the student to leave a drill at any time and then return to that drill at the next problem not yet completed.

3) An option for the student to leave the drill session entirely and to save intermediate results to disk. Upon return to the drills, the student may continue any of eight drills previously attempted.

September-December 1987. We continued pilot testing the Pascal tutorial and Lotus 1-2-3 drill templates. The tutorial lessons were used simultaneously by business education undergraduates enrolled in the Office Education Materials and Methods course.

We addressed the following steps or problems:

1) Remove any remaining bugs in software.
2) Develop additional problem sets arranged by problem difficulty. This has continued after pilot testing.
3) Multitasking of Pascal tutorial with Lotus 1-2-3 drills. We found that this is not possible.
4) Development of written materials in parallel with the software, to supplement existing textbook materials.

January-March 1988. We continued pilot testing the Pascal tutorial and Lotus 1-2-3 drill templates. Tutorial lessons and accompanying drills were pilot tested with business education undergraduates in two courses: Methods of Teaching Accounting and Data Processing, and Using Spreadsheets in Business Education.

April-June 1988. In continued pilot testing, an experimental and control group of business education undergraduates were established to test the effectiveness of using the Tutorial/Drill combination to teach financial concepts related to the time-value of money. The software we developed was compared with traditional textbook/lecture materials for teaching the same material.

Future Plans

Pilot testing data have confirmed that use of the tutorial and spreadsheet drills is more effective than workbooks and calculators for teaching the same content. We plan to continue refining the tutorial software and to evaluate the materials with different groups of students.

Equipment

1 PC/AT with Enhanced Graphics display
9 PC/XTs with Enhanced Graphics displays
4 PCs with color displays
8 Proprinters

Project Number: ED04

The Development of Courseware for Reading in a Second Language

Dale L. Lange
Department of Curriculum and Instruction

Purpose

The goal of this project is a program for reading in a second language, particularly French, German, and Spanish. This program has been developed by a team from the department of Curriculum and Instruction in the College of Education, and the departments of French and Italian, German, and Spanish and Portuguese in the College of Liberal Arts. Project Assist has supported the project with project design and programming. The following persons have participated:

Faculty
Betsy Barnes, Associate Professor, French and Italian
Leo Duroche, Associate Professor, German
Carol Klee, Assistant Professor, Spanish and Portuguese
Dale L. Lange, Professor, Curriculum and Instruction
Millie Mellgren, Assistant Professor, Curriculum and Instruction
Richard Raschio, St. Thomas College (Consultant)
Ray Wakefield, Associate Professor, German

Research Assistants
Gwen Barnes, Spanish and Portuguese, AY 86-87
Catherine C. Baumann, German, 87-88
Russell Christensen, German, AY 86-87
Franz J. Gadermann, German, St. Olaf College (Consultant), 87-88
Linda Leonard, French and Italian, AY 86-87
Joanne Peltonen, Spanish and Portuguese, Summer 87
Prosper Sanou, French and Italian, 87-88

Programmers
Norman Denler, 88-89
Paul Wieser, 86-88

Progress

In the 1987-88 academic year, this team accomplished the following tasks:

- *LIRE, LESEN, LEER* was pilot tested with 10 students each in French, German, and Spanish in the computer lab in Folwell Hall. For this purpose, the College of Education supplied the necessary funds for student access. The results of this pilot testing were prepared and used for the submission of the program for the EDUCOM/NCRIPTAL software-awards competition. The program received a first-round commendation. As a result of the pilot-testing, we felt that the program needed substantial revision. Project Woksape funded a proposal for slightly over $9,000 for this purpose.

In the 1988-89 academic year, the team completed the following tasks:

- The program was revised considerably. Instead of separate modules for text, clue, question entry, and student program modules, pull-down menus are now available for these different aspects of the program, making its use much simpler for both instructors and students.

- It is now possible to design the keyboard to fit the language, especially for those languages that use the IBM keyboard. It is possible to import other character sets into the program. Eventually, such languages as Hebrew, Chinese, and Japanese could use the program.

- There is much more flexibility available in the student program. The original program was linear in nature: three readings with prescriptive, linear elements within each. In other words, preview and text organization had to be followed by reading one, reading two with clues, reading three, and then questions. In the new version, instructors will be able to "program" the elements they wish to use as students process text in the combinations they determine are appropriate. In other words, should the instructor wish that questions precede the reading of text, followed by the text with clues in first reading, and no recall until the second reading, that configuration can be so defined. Users can also define many other combinations.

- The program can now be defined for a specific class or individual within that class for a particular purpose.

- *Prerequisite Knowledge* and *Advanced Organizer* categories of information can be added to the text as deemed appropriate. The former category includes information necessary to focus the student's prior background knowledge on the text. The latter contains information dealing with the structure of the text.

- The number of levels of *clues* available has expanded to ten. The previous program allowed four levels of clues with eight problem types. Many more problem types could be added to those already designated: 1. lexical, uncommon meaning; 2. lexical, false cognate; 3. lexical, cultural; 4. lexical other; 5. idiomatic expression; 6. anaphora; 7. word order; and 8. morphology.

- *Question types* continue to include T/F items, as well as multiple-choice, multiple-correct, matching, and event-ordering items; new in this version are open-ended questions. Student users of the program will be able to review the text related to many of the questions, as well as to receive feedback on their responses.

- The revised program has been designed not only for instruction, but also as a research tool. Records are kept on such items as clues, time for reading, responses to questions, and amount of recall material. The program could be used in combination with an eye-tracker to examine both eye-movements and recall, as one example of a research application.

- *Presentations.* In addition to development work, the staff has made presentations at several conferences:

IBM ACIS Review of Project Woksape, Minneapolis: October, 1986
American Association of Teachers of German, Minnesota Chapter, Bloomington: October, 1986
Twin Cities Foreign Language Collaborative, Roseville: February 1987
AEP Conference (Poster Session), Boston: June 1987.
American Council on the Teaching of Foreign Languages, 1987
CALICO, Salt Lake City: 1988
University of Minnesota Forums on Instructional Software, 1988

University of Minnesota Project Assist Roundtable, 1988
AEP Conference, Dallas: June 1988.

Equipment

1 PS/2 Model 50 with VGA display
12 PC/XTs with Enhanced Graphics displays
4 PC/ATs with Enhanced Graphics displays
1 PC
3 Monochrome displays
2 Color displays
2 VGA displays
11 Proprinters
1 Color plotter
1 PC Network

Project Number: ED05

Microcomputers in Research Training: Fostering Laboratory Innovations in a New Generation of Researchers

James L. Morgan and W. Andrew Collins
Institute of Child Development

Purpose

The purpose of this project is to develop a component of the graduate training program in the Institute of Child Development that addresses needs in three areas: (1) providing instruction in actual and potential applications of microcomputers in developmental psychology; (2) providing instruction and practice in formulating research needs in terms appropriate for translation into microcomputer applications; and (3) providing supervised practice in the applications of microcomputers in the students' own research.

Progress

In conjunction with meeting our first two goals, several software packages have been developed or are under development. The content and current status of each of these is described below. We have chosen to focus on these particular applications, both because they pertain to different phases of research projects -- administration of an experimental procedure, initial coding of observed behavior, instrumental analysis of behavioral measures, and theory design and hypothesis generation -- and because each application provides a state-of-the-art example of the use of microcomputer technology in behavioral research. The study and use of these prototypical applications will familiarize students with the range of microcomputer uses and provide detailed case studies of the process of devising research applications from top-down structured analyses of research problems.

Administration of an experimental procedure. A common application of microcomputers in developmental psychology laboratories is in controlling the presentation of stimuli and the operation of devices for measuring or recording behavior. A prototypical application designed to administer experiments examining infants' preferences for synchrony in visual and auditory stimuli has been developed. This program can control both visual and auditory computer-based stimuli, activate external devices that may present additional stimuli, and record and code both categorical and time-based measures of behavioral responses. The current version of this program operates on non-IBM laboratory interface and graphics equipment. We have been frustrated in our attempts to adapt this and other programs for use on IBM equipment: despite efforts on our part and on our behalf by the Project Woksape staff, over the past year we have been unable to obtain the required technical information on the relevant adapters. In the coming year, we hope to be able to make these adaptations. In addition, we plan to develop a generalized control program and a menu-driven applications generator so that students may interactively design programs suitable to their specific needs.

Initial coding of observed behavior. Learning how to observe and code behavior is an important component of research training in the behavioral sciences. Problems of observer bias and reliability require that such training be conducted with ample technical support both to ensure precise, reliable, and valid observer coding and to provide rapid methods for behavior coding and analyses. We have developed software at the Institute for flexible on-line coding of both live and videotaped behaviors that can be adapted to a variety of observational research needs. This software can provide immediate assessment of both inter- and intra-observer reliabilities and thus may also be applied to the training of observers.

Future Plans

Instrumental analysis of behavioral measures. Many of the behavioral measures used by developmental reseachers involve electrical signals. Microcomputer technology permits laboratory utilization of digital signal processing, which makes feasible on-line collection and large scale analysis of waveform data. A waveform-analysis program (which has not yet been adapted for use with IBM equipment) has been developed, which will serve to acquaint students with signal-processing techniques. A short series of computer-based tutorials on introductory concepts of digital signal processing and the application of such techniques to behavioral research is under development.

Theory design and hypothesis generation. Computer simulation offers an important technique for testing and refining complex models of behavioral systems. Simulations of problem solving and language acquisition based on the Parallel Distributed Processing model of neural activity are under development. These simulations will be completed in conjunction with a graduate seminar on PDP models to be offered in the coming year.

Planning for our graduate course on research applications of microcomputer technology will continue, with the first (experimental) offering of this course scheduled for either Spring or Fall, 1988.

Equipment

2 PC/ATs
1 VGA display
2 Proprinters

Project Number: ED06

A Computerized Observational Assessment System for Evaluating Instructional Interventions and Providing Classroom Teachers with Precise Information on Students' Academic Engaged Time

James E. Ysseldyke
Department of Educational Psychology

Purpose

The major objective of this project was to computerize a paper-and-pencil observational assessment system used extensively in research, in a way useful for practitioners. The new system is used on IBM Convertible computers to collect detailed observational information on the instructional responses of pupils with learning and behavior problems in school. With this system, information can be summarized and provided immediately to classroom teachers, so that changes can be made in the instructional programs of students with mild learning and behavior handicaps.

Progress

Field testing of the system was conducted during the 1987-88 academic year. We tested the computerized observational system, as well as the coordination of the IBM Convertible computers and the IBM PC/AT for cost-efficient data-aggregation procedures. Field-testing occurred in eight school districts; observational data were collected on over 200 elementary students. Data were gathered in 10-second intervals for half-day sessions. These data were then transferred to the IBM PC/AT for data aggregation and data analysis.

During the field-testing period, we also prepared programming for the paper feedback aspect of the system. The resulting programs enabled observers to provide a teacher with summary information on observations in four formats: (1) a summary of data on major composite variables, observed in minutes and percentages; (2) a detailed record of data on individual variables, observed in minutes; (3) a detailed record of data on individual variables, observed in percentages; and (4) a summary of the completeness of the data (i.e., summary of missed observational intervals). Each of these summaries could be provided within minutes of completing an observation.

The system was used to train graduate students in school psychology and special education in ways to collect and use classroom-relevant information in educational assessments. The system was tested during 1988 in a study of the effectiveness of observation and paper feedback for teachers. Observers recorded the classroom behavior of students with mild handicaps biweekly over a period of approximately four months. First, no observational information was given to the teacher. Then, observational data were provided to the teacher on a summary sheet. Finally, observational data were provided to the teacher by an instructional consultant who examined the information with the teacher and discussed approaches to instruction based on the observational information. Initial analyses of these data suggest that immediately providing teachers with observational information does affect instruction in a way that can produce more appropriate academic response by the student. The system to date has been used with special-education teachers. The disadvantage here is that students responding in special-education situations may be very close to the upper performance limit. The system should be tried in a general-education classroom situation, where students with learning and behavior problems are less likely to be demonstrating desired instructional responses.

Future Plans

During the 1988 field tests, we also used a new qualitative observational system designed to obtain information about other key aspects of the classroom environment. The qualitative observation uses paper-and-pencil procedures to record qualitative information that is later transformed to ratings on a Likert scale. More recently, we have used a scale designed to collect information on interactions between classmates, a particularly relevant variable when students with handicaps are placed in general-education classrooms. This observation system also uses paper-and-pencil procedures. These two paper-and-pencil observation systems yield important information beyond that provided by the current computerized observational system. It is our goal in the future to integrate the two new observational systems with the current computerized observational system. Doing so will involve redesigning the current system, as well as modifying the new systems for integration with the first.

We also plan to examine the possibility of providing feedback from observations to general classroom teachers, to determine whether changes in instruction and resulting changes in student responses are more likely to occur in this situation than in the special-education setting.

Equipment

1 PC/AT with Enhanced Graphics display
1 Proprinter
4 PC Convertibles
4 Convertible printers

Project Number: ED07

Use of IBM Videodisc Technology to Teach American Sign Language as a Second Language

Susan Rose
Department of Educational Psychology

Purpose

The purpose of this project is to address the need for instructional material in support of American Sign Language as a foreign language of study through the use of videodisc interfaced with the IBM microcomputer. While numerous books and print materials are available as instructional support material, these are generally inadequate as a resource for learners. American Sign Language (ASL) is a four-dimensional language using space, movement, body-facial expressions, and rhythm. These features cannot be accessed through print, as is the case in other languages that are auditorily dependent (e.g. English, French, German).

The ultimate goal of this project is to develop six model lessons with practice and evaluation components using the IBM Video Passage System and the InfoWindow Display. Each of the model lessons will focus on the use of ASL in real-life, practical situations. Students will view a passage via the videodisc interface and be instructed to interpret or restate the viewed signed communication in English. (The programs can easily be adapted to native Spanish users, also).

Progress

Current progress includes development of a pilot study to identify if students can learn to sign by viewing sign-language models through the use of level III interactive videodisc technology. Thirty signed vocabulary words are presented in isolation and in a signed sentence format. A VIP drill format has also been incorporated into the preliminary study. The VIP drill differs from traditional drill formats in that an incorrect item reappears with corrective feedback shortly after the item is missed. The signed item is presented repeatedly until it is answered correctly at least twice.

The videodisc has been pressed and the interactive program written and pilot tested. It is anticipated that 30 subjects will be tested on the system during the month of October, 1987. Data analysis and the final report will be prepared in November.

Scenarios have been developed for storyboarding and filming six model lessons in ASL. Contact has been made with several facilities regarding the cost of filming the preparation of a videodisc. The most promising venture at this time appears to be a joint effort with the National Technical Institute for the Deaf at the Rochester Institute of Technology in Rochester, New York.

Future Plans

Pending funding availability, six model lessons will be prepared using level III videodisc technology, the IBM video passage system and the InfoWindow Display. Each lesson will incorporate functional communication in American Sign Language at six different levels of communication competence. It is anticipated that the lessons can be used in high school, college, and university settings where sign language is taught as a foreign language. The lessons may be used to assess student competencies or as an instructional tool. In addition, funding will be sought to install a system with the model lessons in a public library setting. This public access would allow family members of deaf children and others interested in learning ASL, opportunities to learn and practice sign language outside of the formal classroom.

Equipment

1 PC/AT

Project Number: ED08

Educating Professional Judgment Related to Children's Social Development via Interactive Videodisc

Ruth Thomas
Department of Vocational and Technical Education

Purpose

The purpose of this project is to develop an instructional approach by which students are able to more effectively learn to make appropriate and effective judgments in situations affecting the social development of young children. Specifically, the purpose of the project is to develop instructional design and software incorporating a Level III interactive videodisc to develop student thinking processes and use of knowledge in making complex judgments about situations affecting the social development of children.

Complex judgments require synthesis of many different factors. Knowing what the relevant factors are and ways to obtain relevant information about them affects the quality of judgments. The teaching of three kinds of judgment is of particular concern and interest in this project: Judgments of consequences, judgments of compatibility, and judgments of priority.

The instructional design being developed is based on findings in cognitive research that indicate that expertise is related to: 1) selective focusing of attention on cues that are relevant to a problem or situation, so that the problem or situation can be accurately identified and categorized; 2) adopting a role that leads to interpretations, goals, and actions that address the problem in ways that are appropriate for the context; and 3) knowing sets of condition-action associations that suggest action alternatives likely to effectively resolve a problem and meet a goal.

Current methods used to help students learn judgment processes include role plays, simulations, and practica or field experiences. All of these methods are situation-focused, i.e., they involve situations that are considered to be representative of actual situations students will face in their intended professional/practitioner role. Students practice making judgments in these representative situations and get feedback on the quality of their judgments. Use of such approaches has revealed that there is a wide range in students' abilities to cue in on important and relevant factors in a situation, and in the variety and potential effectiveness of the action alternatives students identify and use in resolving the situation. Because visual and auditory cues provide information essential to fully understand and accurately interpret human interaction situations, written material alone simply cannot represent such situations with a sufficient degree of fidelity. Further, instructor guidance is typically limited to very general guidelines offered at the beginning of the learning experience and more detailed feedback following the experience which, in the case of practica and field experience, may be several hours, days, or even weeks after critical learning opportunities have occurred.

The instructional approach being developed in this project is a more explicit and precise approach to teaching the knowledge, functions, and operations that produce appropriate and effective professional judgments in working with children in the context of early education. The approach incorporates: 1) simultaneous presentation of critical visual and auditory cues in much the same way they emerge in actual situations, 2) opportunity for repeated and detailed examination and analysis of a situation and control by the learner over the pace at which a situation is presented, and 3) interjection of instructional guidance at critical times as the situation is experienced and analyzed by the learner.

Progress

The project began during the summer of 1988. Current activities and schedules are indicated below:

1. Production of a two-sided videodisc containing one hour's worth of one- to five-minute video segments
   Completed January 1989

2. Development of detailed instructional design and flow chart as basis for computer program and development of computer program for the IBM InfoWindow system

   Flow chart development was completed in March 1989.

   Seven major components of about 120-170 events each are included in the flow chart. Production of the program and screens is completed for three of the major sections, which involve a total of between 400 and 500 events. Completion of a fourth component is anticipated by June 30, 1989. The three remaining components will be completed in 1989-90.

   In addition to the seven major components, an introduction section and diagnostic test have been developed and completed. In addition to the remaining major components to be developed, assessment and metacognition components will be added to each section. This task is projected for completion in 1989-90.

3. Revisions of completed sections have been made. Further revisions and refinements will be made in 1989-90, when the entire program is completed.

4. Formative evaluation of the instructional program is currently underway and will be completed by the end of spring quarter, 1989. These informal tryout data from students in HEEd 3331, CPsy 3330, and two metropolitan-area technical institute child development student groups is intended to provide input into revisions and further development of the instructional program and to serve as a basis for evaluating the program's effectiveness in 1989-90. Video included on the disc was experienced by students in HEEd 5405 Winter Quarter, 1989. A panel of experts has reviewed the design and initial program production. This group is scheduled to review the parts of the program developed to date on June 8, 1989. Completion is scheduled for spring, 1989.

5. Effectiveness evaluation has been planned at a general level for winter and spring of 1989-90.

6. Reporting and demonstrating results to various University departments was originally planned for 1990-91. This activity has already begun, however, with three presentations scheduled in May 1989: one to faculty and graduate students in Home Economics Education; one to faculty, students, and State policy staff in Vocational and Technical Education; and one in HEEd 5300, the curriculum course taught by R. Thomas this spring quarter. This effort will continue throughout 1989-90 and 1990-91.

Future Plans

Future plans are to continue the project in the way originally planned, for the most part. We now have a much better sense of the project's scope and resource demands as a result of the experience of developing the videodisc and the computer program. Development has become more efficient as we have learned the process of creating the structure and material for an instructional program using this technology. Student responses are positive and reinforce the efficacy of both the design and the method of instruction. Items 2, 3, 5, and 6 above will continue to be addressed in 1989-90. Item 6 is still projected for 1990-91.

A longer-term outcome of this project is possibilities for theory development it has stimulated, and that will be pursued. This theory development is related to thinking processes, knowledge structures, learning, and instructional design. The project has come to represent the creation of a learning environment for teaching people knowledge structures and processes underlying making a complex judgment in a specific domain of knowledge and practice. It represents a prototype of such a learning environment that could be transported to other knowledge and practice domains, especially those in which human interaction is central.

Equipment

1 PS/2 Model 50
1 InfoWindow display
1 Proprinter

Project Number: ED09

Software Development for Behavioral Self-Change

John Romano
Department of Educational Psychology

Purpose

The purpose of this project is to develop software to assist students to first identify and then change those personal behaviors that are problematic for them. Typically, those behaviors create additional stress for students (e.g., speech anxiety), interfere with academic achievement (e.g., poor study skills), and/or increase health risks (e.g., smoking). The software will engage students initially in a personal-assessment process, with the eventual outcome being the identification of a specific goal for behavioral change (identification stage). The second stage of the project assists students in developing a behavioral-change strategy to bring about the desired personal change (implementation stage). During the implementation stage, students will monitor their progress on their personal computer disk. Finally, at the end of the quarter, students will generate a paper that reports the results of their personal self-change project (results stage).

Progress

This project was begun fall quarter, 1988. The content, design, and programming for the identification stage are nearly complete. Help screens are incorporated into this stage to assist students if they need it. For the implementation stage, much of the content is written, and programming is underway. Throughout the program, we are making help screens available to offer additional guidance when needed. Version 1 of all three stages should be completed by August 1, 1989.

I plan to pilot this version in the General College class, Psychology of Stress Management (GC 1705), in Fall Quarter, 1989. Since many of the students who will pilot-test the program will be lower-division students, I anticipate that many of them will be unfamiliar with computers. Therefore, I have attempted to make the software as easy-to-use as possible. I thus expect that, as a result of this assignment, students will not only learn about the process of behavioral self-change and perhaps realize a positive change, but also become more comfortable with the computer.

Future Plans

After the initial pilot-test, adjustments will almost certainly need to be made. Therefore, after Fall Quarter, I will begin to develop Version 2 of the software. I will also discuss with faculty its potential use in other courses. I believe that there may be a market for this type of software outside the University community, and I intend to explore this potential after refining the program. Finally, during Spring Quarter 1990, I will introduce the software to a graduate-level practicum class in counseling psychology. Graduate students can not only assist with refining the software, but also use the software as an adjunct to counseling.

Equipment

1 PC/XT with Monochrome display
1 Proprinter

College of Natural Resources

Impact of Project Woksape on the College of Natural Resources

Thomas E. Burk, Associate Professor and Computing Coordinator

The College of Natural Resources is dedicated to the undergraduate and graduate education of men and women in natural-resource management, protection, and utilization, to the furtherance of basic and applied research in areas related to natural-resource science, and to the dissemination of natural-resource information through extension and continuing-education programs. Natural-resource-based agencies and firms have traditionally been heavy users of computer technology. In addition to such standard applications as accounting and budgeting, computers are used to maintain and analyze large data bases of resource information, run models that predict the impact of management practices on the resource, and evaluate alternative utilization strategies for the results obtained from management. Many of these applications have elements unique to natural-resource management. Thus, it is critical that College of Natural Resources students become comfortable using computers and be trained to formulate problem solutions using computers. For this to occur, computing must be fully integrated into the College's curricula.

The College has been fortunate to have four projects funded by Woksape that have great potential for enhancing the computer experience afforded students. All four are aimed at incorporating applicable, contemporary research results into existing courses. Three of the projects have elements based on artificial-intelligence concepts, and all four in some way use simulation as a vehicle for delivery of instructional content. Two of the projects are envisioned to take special advantage of the newest hardware and operating-system capabilities offered by IBM's latest personal computers. One of the projects was selected for further development by Woksape under the Windows environment; the software from that project has been one of the University of Minnesota projects on display at the two IBM conferences on instructional computing.

Three of the projects are headed by faculty from the Department of Forest Resources. The software being developed in these projects allows students to simulate alternatives and impacts of timber and watershed-management activities and apply powerful remote-sensing techniques to the analysis of natural-resource data. All three have been implemented to some degree in individual subject-area courses. These initial experiences are being used to identify how program interfaces can be improved for the intended student audience. Although the three projects were developed independently, a long-term objective is to combine them and two related projects in Forest Resources into an integrated package to be used across a number of courses. Such a package would allow students to study, for example, the impacts of harvest-scheduling activities on watershed conditions. Further, both timber and watershed management have complex spatial components best handled using image-analysis and geographic-information-systems tools. This package of simulation/analysis tools will bring students in the College closer to our goal of complete integration of computer instruction into all sub-fields of natural resources.

The fourth project is being conducted by two faculty members in the Department of Forest Products. This project involves binding artificial-intelligence concepts to a model of a paper-mill system. Although this is the newest of the College's Woksape projects, the pulp-mill simulation system has already been implemented in two Forest Products courses and has received very positive feedback from students.

All project coordinators feel their experiences to date have been highly successful in stimulating their teaching and research endeavors and look forward to other unique opportunities Project Woksape funding will provide for improving the College's instructional capabilities.

College of Natural Resources support for Woksape-funded projects has been outstanding. In addition to the usual resource and faculty time commitments, the College has developed a new microcomputer laboratory with 31 microcomputers and associated peripherals. This laboratory provides the means of effectively transferring the results of Woksape projects to students in a classroom setting.

Project Number: FOR01

Linking the Disciplines for Improved Forest Resource Planning

Dietmar Rose
Department of Forest Resources

Purpose

Forest planning, due to long planning horizons and the associated uncertainty, has been recognized as a complex and difficult undertaking. To assist in forest planning, quantitative tools have been developed for various aspects of the planning process, i.e., forest inventory and growth, silvicultural expert systems, stand-level investment analysis, spatial analysis, harvest scheduling and geographic information systems (GIS). However, few of these models have been linked and been fully integrated. Our approach has been to develop an integrated forest planning package that allows user interaction and intervention in the planning process while automating the linkages between the various components.

A microcomputer-based system facilitates the development of optimal operational and strategic forest plans. It integrates a database-management and geographic-information system with two major planning modules. The first, an automated stand-prescription writer, uses a silvicultural expert system for Lake-States species to automate the process of developing stand-level alternatives over a full planning horizon. These alternatives become the input into the second module, a management scheduling model based on the Hoganson-Rose algorithm. The algorithm, in contrast to conventional LP solution techniques, overcomes many of the problems of data aggregation which is normally required for LP-based harvest scheduling models. It can solve problems of virtually unlimited size in terms of the number of distinct land management units recognized. The module linkages make it easy for the planner to concentrate on output interpretation and analysis of many development scenarios.

Progress

Dtrees is a menu-driven shell program that links four quantitative forest-planning components in a fully-automated software package. It uses a silvicultural expert system (Brand 1981) to make harvest prescriptions. It uses the GROW subroutine from the STEMS growth model (Belcher, et al. 1982) to project tree lists and a regeneration model (Ek and Brodie 1975) to regenerate stands after final harvest. Through a user-controlled process, the system produces a list of alternative prescriptions for each stand over the entire planning horizon. This list of feasible stand prescriptions is then fed into the fourth component, a harvest-scheduling algorithm called Dualplan. Dtrees, including a user's manual, has been completed and tested.

DualPlan is a microcomputer version of the Hoganson timber harvest-scheduling algorithm (Hoganson and Rose 1984). Due to the size and complexity of strategic planning, stand aggregation has been used to reduce the problem size to a level which an optimization algorithm such as FORPLAN (Johnson, Jones, and Kent 1980) could handle. The result of an aggregated planning approach was a strategic plan that was not linked to an on-the-ground, operational plan. The Hoganson algorithm, through problem decomposition, is able to optimize on an operational level without aggregating the input data set. Thus, the strategic and operational plans are linked, while an optimal harvest schedule is obtained. A prototype of DUALPLAN is operational and has been tested.

Future Plans

While both DTREES and DUALPLAN can be run as standalone modules, they will be linked for integrated planning purposes. We are currently developing a program that takes the biological-management alternatives generated in DTREES to produce the associated economic-management alternatives. This program, based on the structure of each timber stand and user-generated harvesting and product utilization options, generates economic cash flows for the silvicultural management alternatives. These economic alternatives are the key input into DUALPLAN. A prototype of the fully-integrated planning package should be finished by June of this year. Work in several additional areas also continues. This work includes a database-management report writer, which will summarize the output data into usable management information, and a geographic information system (GIS), which will allow analysis of the spatial dimensions of the harvest-scheduling solution. In addition, other research groups within the College of Natural Resources are modifying and improving the basic growth and yield models and regeneration models already in use in the planning system. We anticipate many future enhancements of the system.

Due to the size and complexity of this planning system, a modern database approach and use of advanced systems analysis and design tools is critical to proper and efficient development. One of these tools, Excelerator, has been acquired from outside sources and is being used in system documentation and design. This package maintains full system documentation in a computerized format, providing tremendous savings in time and effort when system modifications are made. The geographic information system, SPANS from Tydak, has been acquired to enhance our ability of interpreting and analyzing spatial solutions.

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Equipment

2 PS/2 Model 60s with VGA displays
2 Proprinters
PC Network

Project Number: FOR02

Satellite Image Processing on the IBM PS/2 Microcomputers: Algorithms for Display and Analysis

Sean Ahearn
Department of Forest Resources

Purpose

The purpose of this project is to design algorithms for display and analysis of satellite imagery that fully utilize the architecture and capabilities of the new IBM PS/2 computers and peripherals.

Progress

Three areas of development are discussed below: image display, image I/O, and analysis.

Image display

Image-display routines have been developed that enable a user to load an image up to 3500 x 3500 pixels into memory while loading a sampled image onto the screen. A 256 x 256 roam window can be opened, in which the image is displayed at full resolution as the cursor moves through the sampled image. The roam window can be zoomed to as many levels as desired. Training statistics can be generated for any point or area in the zoom window. Those statistics can be displayed as a graph of mean values and variances. All bands in the data file, not just those displayed, can be analyzed. Stretches can be performed on the image bands to maximize the use of the 256 colors available on the 8514 graphics monitor.

Image I/O

The data structure used to store images is a pixel-interleave format. All standard I/O routines are available for reading and writing subsets, pixels, or image lines.

Analysis

Routines have been developed for cluster analysis; image classification; principle components; hue, intensity, and saturation transformations; and we are initiating geometric correction procedures.

Future Plans

All or parts of these routines are being transferred to the College of Natural Resources Computer Lab for use in two remote-sensing courses offered by the Department of Forest Resources. The software will also enhance ongoing research efforts at the University of Minnesota Remote Sensing Laboratory.

Equipment

2 PS/2 Model 80 with 8514 display
3 Optical disk drives
1 Proprinter
PC Network

Project Number: FOR03

Computerized Hydrologic Impact Assessment for Natural Resource Managers

Kenneth N. Brooks, Paul K. Barten and Thomas W. Hieb
Department of Forest Resources

Purpose

This project will produce fully interactive, microcomputer-based software for instruction and extension use in wildland hydrology. The impact of common land- management practices such as timber harvesting, wetland drainage, and peat mining on streamflow will be demonstrated with a process-oriented hydrologic model. A successfully tested prototype (the Peatland Hydrologic Impact Model) will be upgraded to include three independent, physically based, land-type submodels: for undisturbed wetlands, mineral-soil uplands, and drained wetlands.

The model will be written in FORTRAN 77 on the IBM PS/2 Model 60 requested for this project. Input requirements will be limited to commonly available climatic, forest-inventory, and soil-survey data. This should maximize the usefulness and portability of the model. This software could also be interfaced with other forest-resource models (e.g., growth and yield projections, harvest scheduling, fire management, wildlife management, economic appraisal) to demonstrate the interdisciplinary approach needed for land-use planning.

Self-guided exercises using actual field data from long-term studies by the Department of Forest Resources, USDA Forest Service, and Minnesota Department of Natural Resources will encourage students and practitioners to examine the effects of their decisions on flooding, annual water supplies, and seasonal flow regimes. These exercises will illustrate typical watershed conditions in the Lake States region, and the practical constraints of multiple-use sustained-yield resource management.

A comprehensive user manual will provide a concise explanation of the model's overall structure and function. Complete, step-by-step examples will be included to directly illustrate model applications. Exercises will focus on the key processes (e.g., forest evapotranspiration, soil-water storage, shallow subsurface flow, snowmelt) that affect streamflow from wildland watersheds. Graphical displays of the model output will allow the user to compare before and after conditions of the watershed. During development of the interactive interface, and the user manual, it will be assumed that the user has no previous experience with microcomputers. The model will be used in five courses, with a combined annual enrollment of 65 to 100 students.

Progress

We are actively using and modifying the software developed with Woksape support for classroom instruction and for future application to environmental-impact assessments. There is considerable interest in this model, which is keeping us going.

Future Plans

Our next step is to make the technical hydrologic computer model PHIM (Peatland Hydrologic Impact Model) more user friendly. We will be carrying out these modifications over the next 12-18 months, with some technical revisions added as a result of field research.

Equipment

1 PS/2 Model 60 with 8512 display
1 Proprinter

Project Number: FOR04

Parallel Processing for Forest Products Procedures

B. Franck and R. Rouda
Department of Forest Products

Purpose

The initial intent of the work was to maximize the profitability of forest-products manufacturing operations that depend on the overall planning, coordination, and control of production, quality, and energy. Some of the key bottlenecks in the implementation of overall mill-wide automation plans in the industry involve process simulation, data management, forecasting and resource allocation, and production scheduling in real-time. This project was meant to specifically address and resolve the fundamental issues of concurrent calculations and related production-management decisions, interactive simulation, and presentation of the multidisciplinary and procedural aspects of traditional Forest Products processes. One constraint imposed on the project was to deliver the programs on a microcomputer such as the IBM PS/2 Model 80, which was the granted computer.

The educational emphasis of the project was on developing and increasing the ability of our students to solve realistic problems related to engineering aspects of a multidisciplinary department, which is populated by marketing, production management, wood science, paper science, and engineering students. The object was to interconnect first-principles as taught in the traditional engineering curricula, and ''expert'' knowledge traditionally acquired by effective work experience, and combine traditional procedural methodology with descriptive knowledge in problem solving.

Progress

The major difficulty encountered in the project was the modeling of a complex and large-scale industrial system, such as a paper mill, on a relatively small computer. Multi-tasking and combination of symbolic and numeric processing offered by the operating system are very useful tools, but they are inadequate by themselves to tackle the information processing required for such simulation.

Two avenues were possible for the implementation of the initial goals:

1. Use existing programs, such as ''FlowCals'' (developed by one the PIs) and an existing expert-system shell such as Personal Consultant Plus (tm); and provide an interface between the procedural and descriptive applications by use of the OS/2 operating system environment.

2. Investigate the fundamental characteristics of the human mind with regard to handling complex systems and model that ability on a computer.

The first avenue was viewed as a faster way to develop an educational program because it ''only'' required implementing an interface program. The major academic disadvantage of this approach in the eyes of the investigators was the short-term value of the work, because it mostly used existing knowledge.

The second avenue, on the other hand, by looking more deeply at the fundamental cognitive ability of the human mind, could provide access to long-term research and be applied in education or industry, and in engineering or less procedurally-oriented domains of knowledge. In spite of the much longer time frame, by comparison to the first avenue, before a prototype could be tested in a classroom environment, the second approach was deemed more successful and complete.

The work was and still is conducted on a theoretical and multidisciplinary basis, in an attempt to develop a domain-independent framework to model complex systems at multiple levels of abstraction. Two particular domains are used as testbeds for the approach: A paper mill is modeled to provide a model of an existing system, and the design of wood structures is used to investigate the fundamental nature of the design reasoning.

Future Plans

Additional research is underway for the development of a general cognitive framework to simulate the human mind's ability to deal with complex systems, to investigate generalized qualitative-reasoning approaches, and to apply these techniques to the simulation of complex systems. Corresponding computer developments will gradually implement the theoretical models for educational/industrial applications. The developments will result in a domain-independent and AI-based simulation shell.

Equipment

1 PS/2 Model 80 with 8514 display
1 Proprinter

General College

Impact of Project Woksape on General College

David L. Giese, Professor and Head, Department of Science, Business, and Mathematics

Project Woksape and Commitment to Focus (CTF) are probably unrelated projects in the minds of the average University of Minnesota faculty members. Their effects are intertwined, however, for General College faculty. For most of the 1985 calendar year, General College faculty debated the CTF proposal that General College give up its degree-granting programs and concentrate on the development of curricula for students who require special preparation because of personal circumstances or previous education. General College faculty needed additional support and incentives to change the direction of their teaching and research when the regents endorsed the CTF revised mission for the College. Project Woksape, along with other development projects, provided some of that incentive and source of support. The faculty developed eight proposals during the first round of open competition.

While only one of the proposals was funded at that time by Project Woksape, all the proposed projects have had a significant impact on General College. Several faculty from our writing staff are actively pursuing research and curricula that involve computers. In the one funded project (GC01), faculty teaching writing use the computer as the only means of communication in the classroom. Other faculty in other College-supported projects are including more limited use of computers in their writing classes. A second project (GC02), which proposes to develop a computer-based assessment program for developmental mathematics, was funded during 1986-87 and is in its initial development. Computerized Behavioral Assessment of Student Learning Styles (GC03) was funded during the summer. The three funded projects represent the type of research of interest to General College faculty and the significant assistance the College has received from Project woksape.

Project Number: GC01

An Interactive Computer Network to Empower Basic Writers

Geoffrey Sirc
Division of Arts, Communication, and Philosophy

Purpose

The purpose of this project is to allow basic freshman composition students, who traditionally have great success with using a computer, the ability to use a networking computer environment for their writing. A LAN would assist beginning writers in two ways. First, with a LAN's ability to link all system users together, writers would be truly interactive with each other and their teacher, and collaborative efforts in writing education could actually take place. Secondly, since the LAN I proposed to use, CompuTeach's adaptation of Fox Research's 10Net, has utility features allowing all communication between users to be done very flexibly in writing, the increased attention students would have to give to writing and reading would be beneficial for basic writers, allowing them increased saturation in written syntax.

Progress

To date, I have run four sections of basic writing courses, each with ten students, in the networked classroom during both Winter and Spring Quarters, 1987. Three of these courses were targeted for mainstream basic writers, one for hearing-impaired basic writers. Lecture classes were kept to a bare minimum. Students used the computers for two main purposes: Obviously, they used word processing to do the writing for their courses; but they also made extensive use of the network's interactive dialogue feature. This feature, which made communication between network nodes possible, initially allowed the writers to discuss writing among themselves -- how they felt about writing, the problems they had -- it was a means of immersion into both the technological system and the discipline of writing. Then, students ''talked'' with each other about paper topics for their future assignments. Thus, the interactive dialogue utility allowed the writers to brainstorm their topics and to discuss various ways of ''solving'' the writing problem inherent in the assignment. This use of the LAN is powerful indeed for basic writers: it both allows them to immerse themselves gradually in the writing situation, overcoming any writing anxiety, and also lets them see the thought processes of their fellow classmates, showing them that others may be having trouble as well, and letting them see other ways to solve the writing problem -- ways that they, too, might successfully exploit. it should also be noted here that another benefit of the LAN (at least, this is my early perception) has to do with the way in which students seem much more comfortable ''discussing'' their own writing, in writing, over the network, than they would in a traditional, oral peer-group conference.

The final use of this particular utility was to allow students to discuss -- again, in writing -- papers that they had written. Students would circulate drafts of their writing (we have not moved to an entirely paperless classroom yet, although the LAN permits that) to their peers, read them, and then use the network to ''talk'' among themselves about each paper. I have found this to be a highly significant use of the network, particularly given the fact that the 10Net network has a utility function that saves transcripts of written "conversations" among users. What happens, then, in a class, is that writers will take the printout of the conversation about their papers and use that to guide their revisions. I have not yet done quality ratings of the papers, but my initial response indicates that many writers improve significantly, given this record of collaborative discussion about their writing to incorporate into subsequent drafts. It should also be noted that the LAN is proving a highly efficient delivery system from the teacher's point of view. Materials can be quickly shipped to each user node, and especially group writing and revising become highly productive, as the results are seen on each student's screen immediately. I have already been able to disseminate my early findings regarding the project in a journal article and at an international conference on computers and education held in Canada last spring. The response to this work is gratifying.

Future Plans

For the upcoming year, I will first get acquainted with the new network software that CompuTeach delivered and installed this summer. It allows greater flexibility for the users -- they will be able to call up word processing, for example, from any point in any utility. There are also benefits for the researcher as well, as the transcripts mentioned above can now be sorted according to time-on-task and user (i.e., I can quickly see all the commentary made by Student X during a session). The analysis of the data so far has taken several directions. First, I am looking at the overall benefits a local-area network affords the composition class. I am also looking at our more specialized group of hearing-impaired users to see if the LAN offers a more powerful transition to Standard Written English for this population. More specifically, though, I have taken advantage of transcripts of students "conversations" about writing in general and the writing that they review and comment on, in order to analyze the way a student writing community is formed: How does a student speak about writing? What metaphors are used? What does that tell us about a student's conceptualization of writing? How does the individual student writer begin to interact with his/her peers to form a writing community? Do they change -- over twenty weeks -- in the way they speak of writing, in the topics that become the locus of their discussion? Are there important gender, age, or racial differences that can be helpful to identify? My inquiry, then, has moved in the direction of the ethnography of communication. This seems particularly fitting, given the social nature of a computer network. In terms of pedagogy, I also plan on setting the groundwork during the upcoming year to bring other groups of writing students in to discover if the LAN has benefits for other populations. One that immediately comes to mind is a Business Writing class, which may work well in an environment that truly mirrors the corporate workplace.

Equipment

1 PC/AT with Enhanced Graphics display
5 PC/XTs with Enhanced Graphics displays
6 Proprinters

Project Number: GC02

Computer Adaptive Assessment in Developmental Mathematics Courses

Laura Koch and Joan Garfield
Department of Science, Business, and Mathematics

Purpose

The purpose of this project is to implement a program of computer-adaptive testing in General College developmental mathematics courses. These courses currently serve more than 500 underprepared, non-traditional students each year.

Pencil-and-paper diagnostic instruments now in use only approximate students' mathematical deficiencies, sometimes resulting in time spent studying entire units when only one aspect of that unit was actually needed. The use of computer-adaptive testing will provide more accurate diagnosis of student skills and deficiencies and will lead to better prescription of appropriate instruction for students.

The project involves acquisition of computer hardware and software, construction of test items, programming to link test results to appropriate areas of instruction, and evaluation of the testing and placement program.

Progress

During the 1986-87 year, the primary goal has been to acquire and set up the hardware and software. Two of the three computers have arrived and been installed, and the software needed has been ordered and will be delivered by August 30. The project investigators have collected existing test items from a variety of college instruments, and are in the process of linking items to specific course objectives.

Future Plans

Once the third computer (the server for the network) is delivered, the software (MicroCAT) will be installed.

Then items will be entered on the computer so that student information may be gathered and used to estimate parameters of difficulty, discrimination, and guessing.

Equipment

1 PS/2 Model 60 with VGA display
3 PS/2 Model 50s with VGA displays
2 Quietwriters
1 Proprinter

Project Number: GC03

Computerized Behavioral Assessment of Student Learning Styles

Gloria B. Wood
Division of Social and Behavioral Sciences

Purpose

The purpose of this project was to design an interactive, computerized program to assess and identify individual learning styles. Learning problems or learning sets were created using IBM Pilot and PC Pilot with four potential problem-solving approaches or learning strategies, based on four established and identifiable learning styles (Kolb, 1981). The goal of the project was to assess learning styles directly and empirically via interactive computing by observing directly what strategies students actually chose to solve potential problems or learn a particular set of materials.

Progress

The software program to assess learning styles interactively was completed in December 1988, using IBM Pilot and PC Pilot. The program was given a trial run with students in a pilot project during Winter Quarter 1989. Students were recruited from four sections of The Psychology of Personal Effectiveness (GC 1701). The 41 subjects in the pilot group were individually directed through the program by a research assistant (though the program is essentially self-directing). The subjects also completed the Kolb Learning Style Inventory, which is a paper-and-pencil instrument for assessing learning styles.

The preliminary data analysis has begun, with correlational and factor analyses. It is clear that the software-assessment program is measuring several basic factors -- more than originally intended. Further analyses are in progress.

Future Plans

It is likely that we will need to modify the software program, deleting some items and adding others. Students will test the program again in Fall Quarter 1989. Analyses and modification, with the usual validation, cross-validation, and reliability estimates will proceed until a satisfactory learning-styles-assessment program has been achieved.

Following success of the current project, the next logical step would be to design a system to teach students how to make learning-style transitions; that is, how to use new learning strategies other than their own preferred learning style.

Equipment

1 PC/XT with Enhanced Graphics display

Institute of Technology

Impact of Project Woksape on the Institute of Technology

Russell K. Hobbie, Associate Dean and Professor

Thirty-two projects in the Institute of Technology have been funded during the course of Project Woksape. I have commented on the accomplishments of many of these projects in earlier reports. Seven projects in this final report caught my attention.

IT10 Professor Richard Kain has developed several programs that help the student explore various aspects of electrical engineering.

IT11 Professor Michael Shur is developing a program that simulates the physics of semiconductor devices. His report shows a beautiful progression from an initial implementation in BASIC, to an intermediate version in Pascal, to the current development in the Windows environment. Much of the work was done by undergraduates as their senior design project.

IT12 Professor Fred Bailey has developed programs for the design of control systems and has been able to try them with a pilot group of students.

IT12 Professor Paola and colleagues now have two years' experience using the RT PC and the PHIGS system in the structural-geology teaching laboratory. They continue their work to use the system in other courses as well.

IT29 Professors Albertson and Mohan have developed a student-oriented user's manual so that a complex research program available in the public domain can be used in undergraduate electrical engineering laboratories.

IT30 Professor Tsai and colleagues have completed their tool for generating software test cases automatically.

IT32 Professor Slagle and his colleagues have provided computer access for disabled students. Seven students are using the equipment; the group is trying to expand the number of machines available, so that more students can be served.

I am pleased to have this opportunity to express my appreciation to IBM for the benefits that Project Woksape has provided the Institute of Technology, and to all of the investigators for their efforts and creativity over the past several years.

Project Number: IT01

Lower Division Courses

Donald R. Riley
Department of Mechanical Engineering

Purpose

The projects IT01 through IT09 represent a departmental plan to integrate computers throughout the entire mechanical-engineering undergraduate and graduate curriculum. This plan is in response to industry trends toward computer-integrated engineering and manufacturing, and directives from the Accrediting Board for Engineering and Technology. Under this plan, mechanical-engineering students would utilize computers in all four years of their program.

The objective of this particular project is to enhance and develop materials for two lower-division courses in Mechanical Engineering: ME 1025, Engineering Graphics, which every freshman student in Mechanical Engineering, Aeronautical Engineering, and Civil Engineering is required to take; and a new course yet to be developed, M. E. Computation, a requirement for all mechanical-engineering students before they enter the upper-division course sequence. These two courses will provide the computer foundation for entry into the upper-division program.

The original objectives proposed for each course are listed below:

A. *ME 1025: Engineering Graphics*

Convert existing software which runs on Terak 8510a microcomputers to run on the PC/AT Professional Workstation and enhance the software to take advantage of the advanced capabilities of the workstation. The programs to be converted include: DRAW, a simple 3D wireframe program currently used in the course to reinforce 3D projective concepts; MINN/DRAFT, a 3D computer-aided drafting package; and NCFILE, which provides an interface between MINN/DRAFT and numerically-controlled milling machines, for exposure to computer-aided manufacturing concepts.

Enhance these packages to take advantage of the expanded capabilities of the PC/AT workstation: expanded memory, improved computational capability, color, high resolution, and improved dynamic capability.

B. *Sophomore M.E. Computation Course*

Develop course outline, assignment material, supplementary material, and supporting software. This course development will involve close cooperation between all divisions in the department to insure that the material coincides with the needs of the upper-division courses, and that additional computer requirements for each of the upper-division courses take advantage of and interface with material developed in this course. This course forms the core of a departmental plan to integrate computer use into the entire mechanical-engineering curriculum.

Progress

Engineering Graphics. The DRAW program has been converted and pilot tested. MINN/DRAFT has been converted for the AT, but limitations in the IBM Professional FORTRAN compiler and linker slowed progress. We are currently using the Microsoft FORTRAN compiler, Version 4.0, and linker, and have been able to get most of the code running. The NCFILE software and another module, NCLATH, for numerically controlled lathe operations, have been converted. An additional program has been developed to introduce students to the concepts of solid modeling: MIGMEP (Minnesota Interactive Geometrical Modeller for Educational Purpose). The aim of this package is to teach the idea of three-dimensional object operations (perspective, rotation, zooming of the image), surface rendering (light source and color painting), hidden-surface elimination, and intersection between surfaces. For ease of use, only simple geometric objects are available, which requires the user to enter only a few necessary data (e.g., the position of the center and radius for sphere).

The use of interactive graphics in NC-part programming has several advantages. Since the part geometry data have already been created during design using the CAD graphics system, the part programmer is not required to redefine the geometry of the part. The graphics terminal provides a display of the tool path for immediate verification by the part programmer. For rough and finish cutting processes, the use of automatic routines gives a significant reduction in part-programming time. NCLATH is interfaced with the MINN/DRAFT drafting package. The MINN/DRAFT data base is translated and used to create the CLFILE of the part. A CLFILE can be generated automatically and/or manually. NCLATH has the capability to do the rough and finish cutting processes automatically. The CLFILE is converted into machine commands for the EMCO COMPACT 5 CNC Lathe. The machine commands are downloaded to the lathe. Finally, the user can machine the part drafted by MINN/DRAFT.

The course is being modified to revolve around the use of the microcomputer instead of a drawing board. DRAW has already been piloted with students. Full implementation will begin in Fall 1989, with the opening of a new microcomputer laboratory containing the Woksape computers. We are also evaluating several commercially-available computer-aided-drafting and computer-aided-design packages for use in the course.

M.E. Computation Course. The first pilot offering of the course was in Winter 1989. Starting in Fall 1990, this course will be required of all Mechanical Engineering students. Detailed course lecture notes, assignments, and projects are under further development. Software subroutine libraries are being developed and acquired, and will be provided to each student as a starter "tool kit". Students will be expected to add to this tool kit both in this course and throughout their upper-division courses.

Equipment

8 PS/2 Model 80s with 8514 displays
5 PC/ATs with 8512 displays
1 PC/AT with VGA display
4 VGA, 9 Professional Graphics, 3 Enhanced Graphics, and 11 Monochrome displays
1 Colorjet printer;5 Proprinters;3 color plotters
PC Network

Project Number: IT02

Power and Propulsion Division

D.D. Brehob and D.B. Kittelson
Department of Mechanical Engineering

Purpose

The Project Woksape microcomputers assigned to the Power and Propulsion division of the Mechanical Engineering Department are used by a number of people (undergraduates, graduates, visiting researchers, and faculty members) for a variety of activities. Specifically, a substantial number of machine-assembly and circuit-board drawings have been generated via the CADwrite program. This necessitated the purchase and installation of a mouse, which is used extensively. Also, the XENIX operating system has been installed to enable the compilation of some very large computer codes.

The following is an outline of the areas in which significant progress was made during the last year. Projects reported as finished in the 1986 report are omitted here, despite the fact that they continue to be used on a regular basis. Finally, we list the classes and areas of study that are directly impacted by this project.

Progress

Software

- In-house development
  *CEC-76 chemical equilibrium code. Work on adapting the program for use on the microcomputers is complete. The program is in demand from other institutions. The Mechanical Engineering Department sell the microcomputer version of CEC-76 for a copying charge of $60.00.
  *A 2-dimensional turbine-blade analysis program is completely operational under both DOS and XENIX operating systems. The 3-dimensional version of the code is also running, but only with the XENIX operating system. Some portions of the program are not working properly, and the Woksape programmer continues work in this area.
  *An engine-cycle simulation program originally written in BASIC has been converted to Fortran. Work continues in this area to add more features of combustion in engines, the program model more closely the actual process. General Electric has provided us a program that describes properties of steam. The Woksape programmer is working on the user interface shell, to allow undergraduate students to run complete cycles with the program. Currently, it provides single-point conditions only.
  *The Woksape programmer has developed a general-purpose rate- of-energy-release program for engine-pressure data analysis.

- Commercially available
  *We have used CADwrite extensively for both machine-assembly and circuit-board drawings. Since CADwrite is not specifically written for circuit board design, we will order a special-purpose circuit-board CAD program shortly.
  *The programming language capability has been extended to include C and Pascal, in addition to the Fortran, BASIC, and assembler previously available.

*The XENIX operating system has been installed on one machine to provide the capability to compile much larger programs than accommodated by DOS.

Hardware

- We have purchased additional carts for the microcomputers and the x-y plotters, so they can be readily moved into the laboratory. Currently, three microcomputers and two x-y plotters are on carts.
- The GPIB bus on one of the microcomputers is used for communication from the Nicollet digital oscilloscope to the computer. Some data lines from engine experiments must be sampled at frequencies that exceed the capability of the on-board analog-to-digital board. Therefore, the data are collected on the oscilloscope before downloading to the microcomputer for storage and processing.
- We installed a mouse on the microcomputer that contains the CAD software.

Instruction

Undergraduate coursework

- ME 3301, Thermodynamics (computation of thermodynamic properties)
- ME 5442, Vapor Power Cycles (steam property program)
- ME 5443, Turbomachinery (2-D and 3-D turbine blade program)
- ME 5460, Internal Combustion Engines (cycle analyses)
- ME 5703/4/5, Senior Laboratory (data acquisition and report preparation)

Graduate coursework

- ME 8443, Thermodynamic Analysis of Power Systems
- ME 8444/5, Combustion Science (chemical equilibrium): Research Programs
- Solar furnace high temperature reactor
- Biomass utilization in spark ignition engines
- Variable intake valve timing via a Stirling cycle waste heat recovery system
- Total cylinder sampling of a diesel engine
- Influence on engine knock by piston top design
- Coal slurry ignition characteristics in an indirect injection diesel engine
- Operation of a diesel engine on the products of a coal gasification process

Equipment

1 PS/2 Model 80 with 8514 display
5 PC/ATs with Professional Graphics displays
5 VGA displays
5 Proprinters
2 Color plotters
1 4216 Personal Pageprinter
PC Network

Project Number: IT03

Digital Signal Processing and Real-Time Data Acquisition and Control Laboratory

Kim A. Stelson and Max Donath
Department of Mechanical Engineering

Purpose

This project will give students hands-on experience in three areas: digital signal processing, FFTs, and real-time data acquisition and control. In the area of digital signal processing the goal is to provide the students with the means to ask "What if ...?" questions and to obtain answers quickly and easily. This involves developing software that includes FFT analysis, digital filtering, waveform generation, and signal arithmetic and calculus. The main feature of the software should be its convenient and simple user interface. On the other hand, the idea behind the FFT software is to provide a tutorial that illustrates some of the pitfalls of the FFTs. Work in the third area, Real-Time Data Acquisition and Control Laboratory involves enhancing students' ability to use high-level languages in conducting real-time experiments

Because of the similarity involved in developing the FFT tutorial and the signal-processing software, the two are being combined into one package that could be used in a tutorial "lead-by-the-hand" method, or a tool to solve problems assigned in the laboratory. Use of the software doesn't require programming; it is designed to work in an interactive mode and simply involves typing in the desired command. The results are displayed in color graphics, facilitating students' understanding of the underlying process.

The Real-Time Data Acquisition and Control Laboratory software is designed to expand the high-level language function library of IMB's DAAC adapter. The goal is to introduce students to some concepts of data acquisition and digital control without recourse to system-level programming.

Progress

Real-time routine AINOUM for the DAAC adapter was developed and then implemented in the ME 5275 laboratory in the Fall Quarter of 1986. There are several problems, in particular that of system identification, which require that computer input and output tasks be carried out during the same sampling instant. This is a fundamental problem and one that the DAAC software did not address. Therefore, routine AINOUM (Analog Input/Output Multiple) was developed in order to give students an opportunity to conduct system-identification experiments using a high-level language. In addition, a digital simulation of a ship's steering system was developed as a laboratory exercise. Students were required to create software to read an analog signal and convert that signal into the ship's position in the screen.

Currently, work is proceeding on the Digital Processing Worksheet. The Worksheet allows students to create, process, and manipulate signals without programming. The actual worksheet displayed on the screen will contain up to nine graphics windows. Each window will in turn contain a signal in either a time or a frequency domain. Signals can either be generated in the software or read in from a data file. The Worksheet will also provide a set of digital signal-processing functions for analysis of the data on the screen. Results will be displayed in a specified window. Full graphics capabilities of the PGC will be realized through the use of the PROFACE library.

At this point, work is being completed on the parser that will handle commands, including: signal generating functions that create sine, cosine, and other periodic signals; frequency-domain analysis functions, such as FFT and inverse FFT; signal calculus functions, such as convolution, integration, and differentiation; and, finally, signal arithmetic functions.

Future Plans

Immediate future plans are concerned with expanding the set of digital processing functions of the Worksheet. The objective is to create a package that could be used as both a tutorial and a tool in signal analysis. Some of the additional capabilities being considered are digital filter design and statistics.

Moreover, during the coming year we have proposed to develop a working case study illustrating AI tools, as detailed in the original proposal.

Equipment

1 PS/2 Model 80 with 8514 display
4 PC/ATs with Professional Graphics displays
4 VGA displays
3 Proprinters
1 Personal Pageprinter

Project Number: IT04

Computer-Aided Instruction in Environmental Control

Thomas Kuehn and Peter McMurry
Department of Mechanical Engineering

Purpose

This report outlines the software that has been developed in the environmental division for undergraduate courses in heating, ventilating and air conditioning and aerosol science and technology. The programs have been run on the IBM PC/AT workstations provided by Project Woksape. Initial classroom use has begun as the classes are generally smaller than 25 students. The software developed to date is primarily for system simulation to complement the lecture course material. Programs previously run on other machines have been transferred to the PC/AT units. Graphical output has been used to enhance numerical output.

Progress

The following paragraphs provide a brief review of the major projects in progress during the past year.

Heating and Cooling Loads in Buildings -- ME 5604

HEAT2D/WALL2D, introduced Spring Quarter 1987

These programs have previously been used in the course, run on a time-sharing system without graphical output. The programs simulate transient heat transfer through a wall or roof of a building using a finite-difference program. Input data required are wall and roof construction details, thermal properties of the materials, and weather data.

A graphics program shows the temperature distribution in the wall as colored squares representing the nodes. However, this program is inadequate and is presently being rewritten to include both an isotherm-contouring function and a plotting routine to yield a better representation of the results.

Work is also in progress to develop an interactive, menu-driven input program that allows the user to work in either SI or English units. This package is expected to be available for the 1988 Spring Quarter.

Refrigeration and Air Conditioning Systems -- ME 5605

CRAFS, to be introduced Fall Quarter 1987

Airflow in rooms is a significant factor in forced-air mechanical heating and cooling system. The CRAFS program, which formerly required the use of a mainframe computer, has been rewritten to run on the PC/AT in a new, menu-driven format. A contour plotting package plots airflow patterns resulting from a room geometry that a student has selected from menus, thus simulating airflow in the room.

CYCLE, introduced Fall Quarter, 1985

This program simulates an R-12 vapor compression refrigeration cycle. Students are assigned three homework problems of increasing difficulty that require them to understand how the program operates, how to write some modifications in FORTRAN, and how to compile and run their edited version. They were very impressed by this exercise the first time it was attempted, and indicated that this was one of the highlights of the course. A listing of this program was published in the ASHRAE Transactions in 1986.

Presently under development is a plotting routine that allows the user to obtain plots of the system's thermodynamic state points.

General Software Development

For the past six months we have been developing a graphics package that allows a user to construct a fluid mechanics/heat transfer problem on the screen of an IBM-AT. The program uses a Logitech Mouse, along with the PROFACE and PGDRIVE libraries developed by Paul Felix, a graduate student in the Mechanical Engineering Department. Significant work remains to be done before a usable version can be made available to students.

Other Work

Refrigeration Lab -- ME 5703

In this course, an IBM PC/AT is the controlling computer in an automatic data-acquisition system that measures pressure and temperature of refrigerant R-12 in a walk-in cooler refrigeration system, in order to analyze performance of the system. The purpose of this application is to introduce students to a common industrial use of personal computers, without requiring them to spend a great deal of time learning programming details required to make the system operate. This does not substitute for the manual calculations that the students are required to perform. Rather, the computer allows the students to relate their ongoing measurements to the results of their analysis. It also demonstrates the practical utility of a computer in an industrial laboratory.

Token Ring Local Area Network

The Token Ring networking system was installed on two of the IBM PC AT's. It was hoped this would make more storage available on hard-disk by eliminating the need to have duplicate files on different computers, often located in the same room.

The networking system significantly slowed system activities when it was active, however. There were also complaints from users that they had to boot the networking system. Therefore, it is not currently in use.

Equipment

3 PS/2 Model 80s with 8514 displays
2 RT PCs with Advanced Color Graphics displays
5 PC/ATs with Professional Graphics displays
5 VGA displays
7 Proprinters
2 Color plotters
1 Personal Pageprinter
1 Streaming tape drive

Project Number: IT05

Process Modeling for Automated Manufacture

S. Ramalingam
Department of Mechanical Engineering

Purpose

The purpose of this project is to place process modeling of manufacture in the discipline-oriented courses of the undergraduate curriculum: continuum mechanics, heat transfer and fluid flow, and computer-based numerical-analysis methods. Since all processing schemes fundamentally rely on continuum mechanical modeling of flow of solids or liquids, the approach described is feasible and can be implemented as a part of the undergraduate program. The courses selected to implement this project are ME 5260, ME 5262, ME 5264, ME 5266, and Ch.E./Mat. Sci. 5620. These courses address deformation processing, solidification processing, material-removal processing, and polymer processing.

Some processing technologies involve coupled equations of heat and mass transfer (for example, conventional casting). These classes of problems will not be tackled till much later. Instead, deformation processing, where such coupling effects do not exist, was selected as the initial process technology for process modeling. To introduce process modeling and analysis for metal forming, we have devised a series of FORTRAN modules that help to strengthen student background in deformable body mechanics.

To avoid 'cookbook' programs, which call for keying in only problem parameters, the approach used is to develop *structured programs* for the principal mathematical operations. Students are furnished with copies of subroutines and subprograms, with a view to encouraging them to develop complete analysis codes by themselves. These codes typically involve computing principal stresses and principal directions, and evaluating the feasibility of plastic flow -- i.e., fulfilling flow requirements.

Progress

The description below summarizes accomplishments in the development of these **manufacturing-analysis programs** now used in the undergraduate curriculum. The programs are written in IBM Professional FORTRAN with a graphics enhancement library (Proface) developed specifically for the IBM Professional Graphics Controller used in conjunction with the IBM Professional Graphics Display. The programs are designed to be user friendly and visually stimulating. Macintosh-inspired pull-down menus allow ease of movement through the programs, and double-buffer animations are performed when possible to maintain user interest.

Stress Analysis Module. The stress analysis module performs three-dimensional analysis of a user-input stress tensor using Cardan's cubic equation. The 3 x 3 user-input tensor is used to calculate principal stresses, directional cosines, hydrostatic and deviatoric stress tensors, volume strain, and energy densities. The principal angles are then used to orient/rotate a three-dimensional stress cube to correspond with the principal stress directions. The code also evaluates the stress state to check for yielding (plasticity) with Tresca or von Mise's criterion.

Drawing and Extrusion Modules. The drawing/extrusion modules perform an upper-bound, frictionless analysis of a drawing/extrusion process. User inputs for the die angle, the material flow stress, and the initial and final material heights are used to calculate the required drawing pressure and the geometric die-angle relationships for the current case. The drawing or extrusion process is then animated to provide the user with a visual picture of the actual process. Relevant quantities such as the drawing/extrusion forces are computed and displayed.

Forging Module. The forging module performs a plane-strain, open-die forging operation using a mixed-friction type of analysis. User inputs for the material height, width, flow stress, and friction coefficient are used to calculate the maximum and centerline pressures for the current case. The friction hill for the current process is then plotted to indicate where the maximum pressures occur within the material. Finally, the forging process is animated to perform the operation. Work on disk forging, an axisymmetric problem, will be completed shortly.

Rolling Module. The rolling module performs a plane strain flat rolling analysis. User inputs for the friction coefficient, roll diameter, material flow stress, original and final thicknesses, and front or back roll tensions are used to calculate the flattened roll radius, separation force, roll pressure, and maximum possible reduction per pass. The friction hill for the rolling process is then animated to provide the user with a visual sense of the process mechanics. Roll separation force, location of the neutral axis, and effect of back/forward tension on the process are all displayed to enhance the understanding of the rolling process.

Slip Line Punch Indentation. The punch-indentation module performs a frictionless slip line field analysis based on user inputs for material height and punch length. The slip line field for the current case is then drawn, along with its associated hodograph. Hardcopy of the field can be obtained using the IBM Jetprinter. Unlike the slab analysis method, this analysis method portrays the material as a rigid plastic. Quasi-linear governing equations result. The module model introduces finite-difference approximation to solve this class of problems.

Slip Line Field Drawing and Extrusion. The drawing/extrusion slip line analysis is a highly interactive program that draws the slip line field and hodograph for a specific process (drawing or extrusion) based on user inputs for the initial and final material heights, friction coefficient, and half die angle. Values for the centerline pressure, drawing pressure, extrusion pressure, and minimum half die angle are also returned. Hardcopy of the field can be obtained using the IBM Jetprinter.

Classroom experience shows that when finite-difference schemes are used, undergraduates are able to comprehend process modeling concepts beyond those feasible with slab analysis. The paragraphs below describe classroom use of various programs.

Code developed for *deformable body analysis, slab analysis of deformation processing, and slip line field theory* have been introduced in the second processing course (ME 5262). They are currently being evaluated for student comprehension and instructional usefulness.

Although the slab method and the slip line field method provide insight into deformation processing, it is difficult to assess the important strain and strain-rate effects that play a major role in producing defects in parts produced with deformation processing. Therefore, we are introducing *process-analysis tools and methods* that consider strain hardening/strain rate hardening effects.

We have obtained a *two-dimensional finite-element code for elastic FEM analysis instruction*, developed at Cornell University by Professor R. Cooke. This code is available for student evaluation in ME 5262. A decision regarding instructional use of this software will depend on student comprehension of the principles, ease of use, and educational utility of this code.

Code developed for this project is currently used for *deformation process modeling*. *Solidification process analysis* code has been less successful, due in part to lack of student familiarity with computation of time-dependent phase-change problems.

Future Plans

Currently, work is underway to update the graphics/window management library functions to incorporate the Enhanced Graphics Adapter (EGA). This would allow the programs to run on IBM Personal System/2 computers. In addition, a much greater effort is being made to move towards actual process simulations that allow continuous changes in process conditions.

Equipment

2 PS/2 Model 80s with 8514 displays
2 PC/ATs with monochrome displays
2 Proprinters
1 Color printer
1 4216 Personal Pageprinter

Project Number: IT06

Educational Software for Heat Transfer Education

Suhas V. Patankar and Kanchan M. Kelkar
Department of Mechanical Engineering

Purpose

Numerical methods for predicting heat transfer and fluid flow are being effectively used in engineering analysis and design. The strength of numerical methods is their inherent ability to produce detailed information about the physical situation under consideration. Existing courses in this area emphasize the development and use of numerical methods, but rarely are those general-purpose numerical codes used to demonstrate the various physical processes. The importance of a clear and intuitive understanding of the physical processes cannot be overemphasized. Hence, the goal of the project is to develop software that uses numerical methods to help students develop a feel for the various phenomena that occur in heat transfer.

Progress

Performance Standards for the Software. All the programs are designed to be very user friendly. The processes of designing and implementing the programs are explained below.

a) Problem Setup
Using the problem setup procedure, the user should be able to build a variety of problems of varying complexity. The possible range of physical situations that can be constructed should encompass all the important phenomena that can occur in the particular physical process that the program models. The setup procedure should be flexible enough so that the user can change his/her mind or correct mistakes during problem construction. Also, the software should be intelligent enough to issue warnings when the user sets up a problem that is not physically realistic.

b) Detailed Calculations and User Participation
The motivation for developing the software was to help users gain insight into the processes governing heat transfer. Therefore, computations should be viewed as merely a means to generate details about the problem. The user should not be concerned with the details of computation. It is also important that the user is encouraged to anticipate the solution of the problem before it is displayed. This helps in clarifying or verifying fundamental concepts.

c) Display of Results
The method used to display the results should translate the large amount of numerical information into a display that is easy to understand. The underlying physical processes should be immediately obvious from the display. The user should also be able to view the results in different forms, so that all aspects of the results are clearly understood. In addition, the display should be attractive, so that the user is induced to make further explorations.

Implementation. The established performance standards are met through the use of efficient algorithms and judiciously chosen graphics routines. The important details are discussed below for each of the three phases of the programs.

a) Problem Setup
In the programs, a user sees a menu of choices for each parameter of the physical situation being modeled. The values of the parameters can be prescribed independently on any of the many subdomains of the geometry, providing the user the potential to build up an immense variety of problems for study, and to investigate all the relevant processes that can occur in the physical situation being modeled.

b) Detailed Computations and User Involvement
The computational algorithms for solutions of the problems have been optimized to suit the capabilities of a personal computer. In deciding the grid size to be used for computations, a trade-off had to be made between the accuracy of the computed solution and the waiting time. Computations are done on a grid of size 10x10 to reduce the waiting time, and the results are interpolated to a fine grid before displaying them. Although a coarse grid produces results that are slightly inaccurate, it does not in any way affect the qualitative structure of the results. During the waiting time, the user is asked questions that are pertinent to the physical phenomenon being studied. By answering these questions, the user can form expectations about the results and, by comparing them with the correct answer, corroborate or clarify his/her understanding of the physical processes.

c) Display of Results
Results are always displayed in graphical form, since it depicts the underlying phenomena very clearly. For problems in one dimension, the results are displayed in the form of graphs. For two-dimensional situations, the results of the computations are translated into colors using a color scale. Variation in the physical quantity of interest, such as velocity or temperature, is then shown in the form of color field over the domain.

Using the strategies described above, the following programs have been developed.

1) Steady One-Dimensional Heat Conduction
2) Unsteady One-Dimensional Heat Conduction
3) Steady Two-Dimensional Heat Conduction
4) Unsteady Two-Dimensional Heat Conduction
5) Fully Developed Duct Flow and Heat Transfer
6) Laminar Diffusion Flame
7) Air Standard Cycles

These programs are already being used in senior-level undergraduate classes. More extensive use is planned for the upcoming academic year.

Future Plans

A variety of programs in related areas is being planned and developed. Work is also in progress to restructure the existing programs so that the graphics output can be displayed on EGA and CGA monitors, as well as reproduced on color pen plotters.

Equipment

4 PS/2 Model 80s with 8514 displays
4 PC/ATs with Professional Graphics displays
4 VGA displays
3 Proprinters
3 Color plotters
1 Personal Pageprinter

Project Number: IT07

Design Division Curriculum

Donald R. Riley
Department of Mechanical Engineering

Purpose

The objectives of this project were to develop software modules to include all the required junior-level design courses: ME 3201, ME 3203, and ME 3205. Software already developed or under development will be adapted to the PC/AT workstations with Professional Graphics Controllers and further enhanced to use the advanced capabilities this workstation provides. The objective, in most cases, will be to provide a set of software that students can either use as is or enhance and adapt to their particular projects.

An additional project objective was the development of a "Machine Animation Workstation" to assist the student/engineer in evaluating candidate designs as part of the design process, by providing for essentially real-time display of the resulting motions of the system under study. The initial thrust of this project was aimed at an integrated mechanism design package, which involves elements of artificial intelligence and expert systems, and existing kinematic synthesis programs and analysis programs; and which interfaces to much more complex analysis packages. This will involve developing a distributed-workstation strategy that allows this workstation to tie in to the VAX and Cyber mainframes.

Progress

PROFACE and MNGRAF Graphics Libraries. A major development in support of this project, as well as the other Mechanical Engineering projects, has been the development of special-purpose graphics support routines. These support libraries provide high-level graphics tools that relieve the programmer of having to build a user interface from the ground up for every application program. Some of these tools include: 1) Standard 2D graphics with plots and labeled axes; 2) User Interface tools consisting of pop-up menus, graphics windows, and mouse input; and 3) Double-buffered animation for a realistic view of applications involving motion analysis. The efforts to provide these graphics tools have resulted in the development of two graphics packages: PROFACE and MNGRAF, which are available through Wisc-Ware at the University of Wisconsin.

Mechanism Design Software. Several programs have been developed or modified and enhanced to run on the AT workstation for ME 3203 and ME 5203 (Advanced course) students: LINCAGES-4, for four-bar mechanism synthesis and analysis; LINCAGES-6, for six-bar mechanism synthesis and analysis; and KADAM-2, a program for general mechanism analysis, including dynamic effects. We are currently getting these packages to work together as an integrated package and improving the user interface. We are investigating how best to provide links to available drafting software, including our own package, MINN/DRAFT. Several computer-aided instruction modules have been written to introduce students to terminology and important kinematic properties of linkage systems. Animation and student "sketch your own" options provide invaluable insight to the student.

Several universities and companies have acquired copies of these programs. A demo version of LINCAGES-4, the CAI modules, and a program for trial-and-error "sketch" design of four-bars under Microsoft Windows have been placed in Wisc-Ware.

Machine Animation Workstation. The PRO-FACE library was developed to support the Animation Workstation concept on the AT with PGC, EGA, or VGA graphics, and on the PS/2 with VGA. The PS/2 Model 80 provides improved performance over the AT; we have also begun exploring the RT PC workstation with an attached 5081 display system as a more suitable platform for providing the required capabilities. An expert-system shell for general design is under development. For this purpose, one AT has been configured with 9 Mbytes of memory and a PS/2 Model 80 with 12 Mbytes of memory, using Golden Hill Common Lisp Large Memory Development system. A limited prototype of the shell has been tested for design of dwell linkages with reasonable success. An IBM speech-recognition card has been used to provide voice-augmented input for computer-aided design under Microsoft Windows.

Future Plans

Development on the mechanism-design software will continue, with an emphasis on Windows under DOS 4.0 and on the IBM OS/2 multi-window, multitasking environment. Development on the expert-system shell will continue as a long-term project.

Equipment

2 RT PCs, one with 5081 color display
4 PS/2 Model 80s with 8514 displays
2 PC/ATs with Professional Graphics displays
2 VGA displays
1 Color plotter
1 Color printer
2 Proprinters
1 Personal Pageprinter
2 Optical disk drives
PC Network

Project Number: IT08

Robotics Research

Max Donath
Department of Mechanical Engineering

Purpose

We have been using the 6 Degree of freedom IBM 7565 robot as a testbed for ME5271 student projects. Our objective is to give students an opportunity to program a full-scale robot and thus learn about both the limitations and capabilities of robots. In particular, we wish to provide students with a flavor of the problems associated with performing full-scale tasks. Problems usually do not show up on small laboratory-scale robots, since these can only manipulate 'toy blocks'. The projects that we have given our students involve real-world assembly problems drawn from local manufacturing concerns.

Progress

Class Projects

Ball Valve Assembly: Students have been assigned the assembly of a Graco ball valve, consisting of 17 parts, including some fairly tiny seals and O-rings. Although this project has provided some excellent experiences for the students, we have found that it takes an inordinate amount of time for students to familiarize themselves with spatial mathematics, manipulator intricacies, a new programming language, *and* the assembly problem that they are assigned. This problem is primarily due to the fact that students have no working robot assembly programs to use as models from which to draw inspiration. We have addressed this problem by developing modules that illustrate how a variety of part-mating problems can be dealt with in an efficient manner. These demonstrations illustrate the relevant issues to students who are working on other projects.

MnCell Based AML Code Generator: MnCell facilitates the graphic simulation of robots performing a task. This allows one to debug the task program prior to running it on the actual machine. Students have developed and tested a preliminary AML Code generator for driving the IBM 7565 robot. With the code generator, once a task has been programmed and debugged in MnCell, a postprocessor generates an AML file, which is then used to drive the actual machine.

Recently, the robot has been down. There is no entity that provides maintenance for the system at present, so we must address repairs ourselves. We have recently repaired a disk problem, but must still account for a problem on joint #1. A chronic leak must also be isolated and repaired.

Toward the end of this program, several significant problems developed with the hardware. Neither IBM nor third parties provide maintenance for this robot. As a result, present plans are to turn the robot into a number of fluir-power control experiments.

Smith, Richard E. *An Autonomous System for Recovery from Object Manipulation Errors in Industrial Tasks.* Ph.D. thesis, Computer Science, 1987.

Professor M. Gini was advisor on this thesis. A summary of this work follows.

A robot system architecture has been developed that automatically detects part-manipulation errors and recovers from them. The system takes a description of the robot's task, converts it into a specially designed internal representation, and provides an execution environment that handles automatic error detection and recovery. An internal representation describes in detail how the robot should operate and how it should use available sensors to monitor the task's execution. Instead of relying on special-purpose error-recovery code, the system exploits knowledge about the robot's task and environment to analyze errors it detects and then to produce appropriate error-recovery procedures.

A working prototype was developed that demonstrates the feasibility of this approach. Task specifications in the testbed system are written in a manipulator-level programming language called "woktalk". The woktalk language is equivalent in expressive power to typical manipulator-level languages for representing example robot tasks, even though it lacks the features of some languages. Statements in woktalk identify the objects affected by manipulator actions, allowing the system to represent additional information needed for error recovery. The error-recovery system simplifies the task of writing reliable manipulator programs because programs do not have to explicitly program the robot's sensors to detect and handle potential errors.

The Error Recovery Testbed used the IBM 7565 Manufacturing Manipulator controlled by an IBM Series/1 computer running the 7505 Robotic Control Program. This control software accepts input in the AML robot programming language.

The IBM robot connects to the rest of the error-recovery system through the AP Executive software, which operates on an Apple Macintosh. The Macintosh contains two RS-422 serial ports: one is attached to the IBM robot through its console port, and the other connects to the campus Ethernet for communication to the error recovery manager software.

The Manager software consists of two parts: the Preprocessor, which translates woktalk programs into AP forms, and the Recoverer, which generates AP's to recover from errors. The Manager is written in Franz Lisp and resides on the Department of Computer Science VAX Unix system. The testbed is set up and controlled with the Apex application program running on the Macintosh. Apex ("AP EXecutive") communicates with the IBM robot and with the Franz Lisp system that runs the woktalk functions. The prototype executes a variety of manipulation tasks on a real robot and automatically handles errors involving lost, dropped, or obstructed parts.

Equipment

1 IBM 7565 Robot with graphics adapter, display terminal, and printer

Industrial Engineering and Operations Research: Systems Laboratory Project

Patrick J. Starr
Department of Mechanical Engineering

Purpose

The objective was to expose students to selected individual software elements of a Computer Integrated Manufacturing (CIM) system and to give students experience in identifying and managing decision situations that arise in operating a manufacturing facility. The objective was to be met by developing a model of a multi-product manufacturing firm that used software packages that were scaled-down versions of CIM elements, and workstations consisting of fast, large-capacity microcomputers with graphics capability. The result was a four-credit, one-quarter laboratory course that provided experience in planning and operating an Integrated Manufacturing System. The *model* manufacturing facility was used as a "base case", and the laboratory course was conceived in two stages. The first was to study and gain experience with *individual* decision situations and their supporting software using the base case. The second stage involved student-proposed projects to alter the base case to explore *integrated* decisions. Our expectations of the effects of instructional software on learning included:

- Increase in students' understanding of *individual* decision situations and techniques used in Integrated Manufacturing.
- Opportunity for experience with interconnected decisions by engaging students in an *iterative trial-and-error experience*, where previous decisions are modified in a cyclic manner, once their ramifications are determined via computer analysis.

Progress

We have developed the following elements:

1. *Model of a Multiproduct Manufacturing Facility* that includes seven workcenters and a labor force, each having regular time weekly capacities. Workforce size can be changed, and overtime may be specified with added cost. The facility manufactures two products, A and B, which require seven assemblies and 11 raw materials. These are expressed as a Bill of Materials (BOM). The processing times for each product and assembly at each workcenter are known, and inventories of products can accumulate at a cost. Historical data are available for sales of products A and B for the past 36 months.

2. *The Base Case* required selecting nearly 200 consistent numerical *values* to characterize the facility. The individual manufacturing decisions consist of (1) making long-term forecasts for sales of products A and B; (2) deciding monthly production levels of A and B, inventory levels, workforce levels, and any subcontracting; (3) choosing a weekly production plan for the next three months; (4) checking workcenter capacities using the weekly plan; (5) selecting weekly production levels for each product and assembly using the BOM detail and lead times; and (6) checking workcenter capacities at this level of detail.

3. *Graphical Representation of the Integrated Manufacturing System Functions.* A "box-and-arrow" diagram was created by combining

information from many sources, in order to depict the functions, data needs, interactions, and decisions in an Integrated Manufacturing System. Each "box and arrow" was described in detail and includes the functions of forecasting, aggregate planning, setting the Master Production Schedule, Rough Cut Capacity Planning, Materials Requirements Planning, and Capacity Requirements Planning.

Software was developed or adapted to assist with the decisions in each function, and includes:

- STORM (STORM Software, Inc., Cleveland, Ohio) for general techniques

- LINDO (The Scientific Press, Inc., Redwood City, CA) for linear programming.

- LOTUS (LOTUS Development Corp., Cambridge, MA) for spreadsheet analysis.

These were employed as follows:

Forecasting -- The case has "historical data" representing the sales of each product for the past 36 months. The forecasting program of the STORM package is used to provide estimates of sales for the next 12 months.

Aggregate Planning -- The forecasted sales and other data are used in a linear programming model (90 variables, 54 constraints) to determine production levels, regular and overtime hours, backorders, and inventory levels for each forecasted month, in order to minimize total costs. The LINDO package is used to solve the problem.

Master Production Schedule (MPS) -- This is set by allocating the next three monthly production levels over the next 13 weeks.

Rough Cut Capacity Planning -- The hourly loads per week for labor and for each work center are determined and compared to the available capacities. A LOTUS spreadsheet was developed to implement this function. It is done visually, with the MPS adjusted on a trial-and-error basis until feasible loads are established.

Material Requirements Planning (MRP) -- This converts weekly production levels for each finished product into shop orders for every manufactured part and orders to vendors for raw materials. It incorporates lead times and on-hand inventory data. The MRP program of the STORM package is used.

Capacity Requirements Planning (CRP) -- Weekly production levels for each part are multiplied by the appropriate unit loads in each workcenter and then summed across all parts and assemblies each week to obtain the weekly load on each workcenter. A LOTUS spreadsheet implements this function. Computed loads are compared with available capacities, and adjustments made on a trial-and-error basis.

4. A *Menu Program* was developed in Turbo Pascal that offers choices that correspond to various decision functions. Options call for the STORM or LINDO disks as needed, and assume LOTUS is available on the hard drive. The menu is the means by which the student becomes the "integrator", and decides what to do next using the "box-and-arrow" diagram as a guide.

5. *Data Base:* Many of the individual decision functions use common data. For example, the processing time for a particular assembly is used to compute information in three decision functions. Changing a value would require

altering entries in three data blocks, which defeats the idea of "Computer Integration". To address this, a large LOTUS data file was created, containing the BOM, the processing times, and the workcenter capacities, and showing the RCCP, MOS, and CRP calculations. It is roughly 100 columns by 200 rows. Changes to the BOM, lead times, processing times, and capacities can be made in this file, and all dependent changes are recalculated.

6. *Data Integration Program.* The menu is not much help if the student has to read output information from a screen and type it as input to the next package. To facilitate this transfer, a Data Integration Program was written in Turbo Pascal and is called from the menu. It then offers another menu that shows the various data transfers as options. When one is selected, an output file has certain information stripped from it which, in turn, is sent to another file that can be read by the receiving program, so the programs can interact without the student needing to copy and re-enter computed data.

Course Operation

In stage one of the course, background and techniques for the individual decision functions were presented in class, and students exercised the STORM and LINDO packages in open-ended assignments. The Menu program, the LOTUS data base, and the Data Integration Program were exercised in an assignment and then used as a basis for student projects. Each student had a directory containing the menu program, the data base, the Integration Program, and all the files with the base-case data.

In stage two, students were required to alter the base case to explore interesting production-planning issues. They submitted proposals, developed project, and used the software. After two informal offerings as "projects" in a design course (to 21 students), the Lab was offered as its own course in Winter 1989, and eight senior M.E. students enrolled. A survey was prepared, and selected responses are summarized below. The iterative learning cycle was engaged in "very much" by three students, "much" by four, and "some" by one. Computer use in the lab was reported "more"(7) or "as"(1) interesting, "more"(7) or "as"(1) instructive, "more"(5) or "as"(3) motivating, and "more"(6) or "as"(2) frequent than in other courses in the Department of Mechanical Engineering. All thought the two-staged approach was a good way to teach it, and all agreed there should be more courses like it. Seven of the eight students wrote extemporaneous comments; some are:

> "The course is well-designed to give the student a means of being truly creative. By means of opening up a unique problem, the student can dig his/her own hole and problem solve in all directions to his/her satisfaction."

> "Overall, this course was a highlight and bonus to my college education."

> "In a practical sense, I feel a course such as this will prepare us better for the problems we will face in industry, as opposed to the 'study your book and regurgitate information' classes. Until you actually work with MRP and LINDO and other software, you really can't grasp the entire concept of scheduling. You learn rather quickly that many factors influence the schedule and things don't always work out as planned. Industry is very complex, it's not something that you can learn simply out of a book. I think the hands-on approach used in this course will be beneficial."

A paper describing the course was presented at the 1988 National Decision Sciences Institute Conference (November 21-28, Las Vegas) and published in the proceedings.

Equipment

4 PS/2 Model 80s with 8514 displays
3 PC/ATs with VGA displays
1 PC/AT with 8512 display
4 Proprinters
1 Personal Pageprinter
PC Network

Project Number: IT10

Integrated Interactive Instruction for Electrical Engineering

Richard Y. Kain
Department of Electrical Engineering

Progress

Our programs support courses required in the undergraduate Electrical Engineering curriculum. During this year, we have written more software for interactive student use. At the same time, we have created and used some support software for graphical interactions between the student and the computer. This support software may be useful to other projects.

Educational Packages

We have completed ten program packages that relate to junior and senior Electrical Engineering courses:

Convolution: The student draws waveforms or selects some predefined ''standard'' functions. The program convolves two waveforms, giving a result identical to that obtained at the output of a linear system if one of the waveforms is the input and the other the system's impulse response.

Bode: The student positions poles and zeroes on the complex s-plane and asks the program to compute the frequency response of the system. Moving the poles and zeroes corresponds to changing the system design; the effect on the system's response can be seen easily.

Ebers-Moll: The student specifies physical parameters describing the internal configuration of a transistor and obtains the electrical characteristic curves of the device, as predicted by the Ebers-Moll transistor model.

Antenna: The student places dipole antennae on a plane surface and specifies the amplitude and phase of the electrical excitation of each dipole. The computer determines the far-field radiation pattern and displays a polar plot of that important function. Every new response plot is plotted on the same coordinate system using a different color, permitting easy comparisons to understand the consequences of a design change.

Fields: The student positions and specifies the quantity of electrical charge at points within a plane and asks the computer to determine the lines of force developed by the specified charges. Changes in the charge array cause changes in the color used to plot results, for easy comparison.

Amplifier: The student specifies the circuit parameters of a single-stage transistor amplifier, and the computer determines the operating point and the AC and DC load lines, plotted on the characteristics. In addition, the computer will find and display the output waveform and give an analysis of its harmonic content. The student can ask the computer to plot the effects of varying a circuit parameter on either the gain or the operating point. Two different sets of circuit parameters can be considered at the same time and their plots superimposed for ease of comparison.

Smith: The Smith Chart is a nomographic technique for solving certain problems regarding the propagation of electromagnetic waves along an ideal transmission line. This program automates the construction details and provides a graphic display of the chart. The student specifies the parameters of the line and its load. The student can request the computer to plot (and erase) circles, radii, and diameters on the graph. The coordinates of a particular point can be determined by entering the "track" mode, causing the program to display the coordinate values of the current cursor position.

PSpice: Our program provides a graphical input interface to an existing program (PSPICE). The graphical interface allows the student to specify a circuit by means of a circuit diagram constructed from circuit elements listed on the screen. Once the complete circuit has been specified, the student can ask the computer to compute the response of the circuit.

Lincad: Our program provides a graphical input interface to the LINCAD program, which analyzes amplifier circuits. Its description is similar to the preceding.

RLC: In a sense, this is a restricted version of the previous program; this one deals only with circuits constructed from resistors, inductors, and capacitors. It is useful for sophomores who are just starting in Electrical Engineering. Its modes of operation are similar to those of the PSpice program described above.

All of these programs were written in Microsoft Pascal. The Amplifier and Smith chart programs run under Windows. We feel that Windows makes a much better environment for the student and, at the same time, relieves the programmer of a number of details regarding the man-machine interface.

Support Software

To implement these programs, we developed a set of software routines that have general utility. One set performs many graph-management details, such as keeping graphical information organized. We have two versions of this package; one creates programs that run under DOS, while the other runs under Windows.

The other interesting program we have developed is a library file that supports the 80287 floating-point chip for Pascal programs running under the Windows environment. The current Microsoft Windows system does not support the floating-chip, so that replacement of its library program with our new version speeds computation by a factor of 5 or 6 in some applications. The new library can be linked with a Pascal program that will run under Windows.

We have obtained a license to distribute the Windows "Single Application Environment" as part of our program. In effect, this means that the program can run on a system that does not contain the Windows support software.

Future Plans

We will continue to make these programs available to our students and will be encouraging faculty to become more involved with computers in education. We have stopped software development, effective Fall, 1987, except for a low-level, low-priority effort to move some earlier programs to the Windows environment.

Equipment

17 PC/ATs with Enhanced Graphics displays
2 PC/ATs with monochromedisplays
1 Monochrome display
17 Proprinters;2 color printers; 2 color plotters
1 Personal Pageprinter

Project Number: IT11

Microcomputer Programs for Simulation of Semiconductor Devices

Michael Shur
Department of Electrical Engineering

Purpose

The goal of this project is to develop a microcomputer software package for general use in analyzing typical engineering data, specifically for use in simulating electronic semiconductor devices. This package must be easy-to-use, reliable, and inexpensive enough for general use.

The software consists of a general-purpose core for plotting and analyzing of engineering data on a standard two-dimensional graph and a set of peripheral routines for describing specific devices.

Many software packages exist for these applications, but they tend to range in cost from several hundred dollars to several thousand. They generally fun on minicomputers or mainframes and take significant time to learn. Consequently, these existing software packages are generally too expensive for student use, requiring expensive hardware, to which students have no access, and a length of time to learn that students cannot afford.

The target microcomputer for this development is the IBM family of personal computers, because they are widely used. By targeting our development on this set of computers, we maximize our potential market for the software.

Progress

The software has progressed through three stages of evolution. In the first stage, it was fully developed in the BASIC language. This version, written by students for their senior design project, had a number of advantages:

- Since every IBM personal computer comes with BASIC, everyone can run the software.

- Since the source code was distributed, one could easily modify the system by adding new subroutines to model new devices, or by modifying the supplied subroutines to view different aspects of devices.

- With the package, we supplied numerous device-modeling subroutines.

The major problem with this approach was that the user interface was relatively cumbersome, making the package difficult to use. This version of the software, accompanied by lecture notes, has been used by students in our 5660-61-62 course sequence. They have responded quite positively, many even using the software for other courses as well.

The second version of the software was also written almost entirely by students for their senior design project. This version was written in a commonly-available compiled language, Turbo Pascal. Since this was a compiled language, it could run on any IBM PC, without the Turbo Pascal compiler. This version featured a more elegant user interface, which significantly reduced the amount of time needed to learn the system. An additional feature of this version was its support for the development of device-modelling programs written in any language. The disadvantage of this package was that it only included one device model.

The Turbo Pascal version is basically a stepping-stone to the Microsoft Windows version. it is not in general use. We may simply submit this version to the public domain.

Future Plans

The third version of the software is currently in development. This version is being written for the Microsoft Windows operating environment for the IBM PC family. It is written in C, the language used most commonly for Microsoft Windows applications.

The current design of this final version calls for the development of device models in C. Under investigation at present is the possibility of creating an extremely simple language for developing device models. If this is feasible, it would be preferable to the former approach, because one could then dynamically alter the device models. This is an important feature, because it is often the case that, by making very small changes in the code, one can look at a device from a completely different viewpoint, thereby gaining a clearer understanding of the device's behavior.

This version is nearly complete. The core is fully in place. The architecture for developing device models in C is also in place, and one device has been modeled.

Equipment

9 PC/ATs with Enhanced Graphics displays
1 PC/AT with Professional Graphics display
10 Proprinters
PC Network

Project Number: IT12

Computer Aided Design of Control Systems

Fred Bailey
Department of Electrical Engineering

Purpose

As noted in our original proposal, this project is organized around five basic steps:

1. Identification of CACSD (Computer Aided Control System Design) concepts appropriate for undergraduate control classes.
2. Development of appropriate new lecture materials, course notes, and laboratory experiments.
3. Development and purchase of CACSD software.
4. Test of several CACSD projects with a pilot group of students.
5. Expansion of CACSD facilities to provide instruction for full-scale undergraduate control classes.

Progress

To date, four of the above five steps have been completed. An initial set of course notes and laboratory experiments has been completed, but work on this part of the project continues as we gain new experience in testing these materials in the laboratory and lecture courses. Initial results of student laboratory and classroom tests have been extremely gratifying. Details are provided below.

Identification of Appropriate Concepts

A review of current work, recent articles, new books, and software packages led to the identification of three basic approaches to CACSD that are both useful in applications and suitable for introduction in undergraduate control courses. These approaches were adapted from recent work in the design of robust control systems using root-locus and frequency-response design techniques. Course notes based on this material are now being written.

Experience with the new more sophisticated digital control laboratory environment (see below) and the new CACSD software (the Program CC software) has shown that many of the design concepts and tools developed in the lecture can now be integrated directly into the laboratory experiments. This brings a stronger design flavor to the laboratory experience.

Course Notes, Lecture Material, and Laboratory Experiments

The majority of the project effort has been devoted to developing software and notes for a series of seven real-time digital-control experiments using the PC/AT and the IBM Data Acquisition and Control Adapter. A major feature of this software is the Pascal Real Time Control Skeleton, which provides a completely general environment for real-time digital controller design but, at the same time, allows the students to write their control algorithms directly in Pascal. (Previous attempts to give students laboratory experience with digital control have always focused on control algorithms written in assembly language. Because of the difficulties of writing and debugging assembly-language programs, it was found impossible to introduce more than the most elementary control concepts in that environment.) While development of the IBM PC/AT software and experiments has been completed, development of TMS32C25 versions continues as noted below.

Lecture materials based on the three CACSD concepts identified above is also being developed and should be completed during the coming academic year.

Development and Purchase of CACSD Software

Several commercially available CACSD software packages were investigated. The Program CC package appeared to offer features most consistent with the needs of this project and was selected as the primary instructional environment.Additional software for real-time closed-loop digital control was developed locally using the PC/AT plus the IBM Data Acquisition and Control Adapter. This software provides a facility for on-line digital control with all programming done in a high-level language (Pascal), while maintaining the flexibility and rapid execution speeds required for control of mechanical motion. New C language versions of the software are now under development for the TMS320C25 coprocessor.

A nonlinear simulation capability was added with the purchase of PC Simnon.

Tests with a Pilot Group

During Spring Quarter 1987, the new digital-control laboratory experiments and associated software were tested with students from the EE Digital Control Course (EE 5252). These tests were very successful. The new experiments were enthusiastically received by the students. There was general agreement that laboratory experiments were an important addition to the classroom material and provided new insights into the basic issues of digital-control system design. At the same time, we learned a great deal that was useful in developing final versions of these experiments during the following year.

Expansion to Full-Scale Undergraduate Control Classes

Since testing with the pilot groups began, we have gone on to 1) finish the development of digital-control experiments and associated software, 2) continue developing course notes on CACSD, 3) work on integrating the laboratory experiments with the CACSD concepts presented in the lectures, and 4) continue evaluating this material with students in our other undergraduate control courses.

Future Plans

As noted above, one of the main goals of the project was the development of new laboratory experiments in digital control. While this has been accomplished, many of our experiments have been somewhat limited by the slow speed of the 80286/80287 processors in the IBM PC/ATs that we are using as digital controllers. Through a recent gift from Texas Instruments, however, we now have the potential for eliminating this limitation.

After observing the performance of our PC-based digital control experiments at the Project Woksape Instructional-Computing Fair in Spring 1988, Jerry Luecke, University Marketing Strategy Manager for Texas Instruments, Inc. has given us a TMS320C25 coprocessor board, together with associated software and an analog I/O interface, which we can install in a PC/AT, thereby significantly increasing the speed of execution of our control algorithms by a factor of more than 100. In this configuration, the AT becomes the host machine used to compile and load digital control programs that are executed in the TMS320C25.

While the addition of the TMS320C25 processors to our PC/ATs will eliminate the hardware limitations of our present digital controller configuration, the implementation of this new structure requires some additional development work to 1) implement a software structure for controlling the TMS320C25 from the PC/AT and 2) modify the existing interface software (ADC and DAC drivers, etc.), so that the existing control-laboratory programs and experiments can be run on the TMS320C25. These developmental steps are now in progress and should be completed by the end of Summer, 1989.

Equipment

2 PS/2 Model 80s with 8514 displays
2 PS/2 Model 60s with VGA displays
8 PC/ATs with Enhanced Graphics displays
2 Monochrome displays
8 Proprinters
4 Color plotters
1 Color printer
1 Personal Pageprinter
1 Streaming tape drive

Project Number: IT13

Pilot Numerical Laboratory

Greg Sherar and Ted Krauthammer
Department of Civil & Mineral Engineering

Purpose

The project involves the development of a "numerical laboratory" originally encompassing two areas in the fields of civil and mining engineering: geo-mechanics and structural mechanics.

Progress

Geo-Mechanics Area

The programs FLAC and MUDEC are installed on four IBM PC/AT's with Professional Graphics displays. FLAC models continuous materials, such as soil, under conditions of large-strain plastic flow. MUDEC models discontinuous materials, such as sequences. Both programs have extensive graphics support.

The programs have been used by students in the course "Computer Applications in Civil Engineering II" to model assigned problems. The students learn several things from this use of the machines:

a) a "feel" for the way in which soil and rock behave under extremes of load. Normally, it is very difficult for students to acquire this experience, without spending years in the field.

b) experience of modeling. Numerical modeling is an art that is mastered with repetition. The instant feedback from the graphics displays speeds up the learning process considerably.

c) knowledge of numerical algorithms and techniques. In parallel with the modeling sessions, classes are given on the theoretical basis of the numerical models.

Development of an expert system to guide the potential user in the selection of a suitable model was begun but not completed.

The principal investigator for this area of the project, Dr. Peter Cundall, is no longer on the teaching staff of the CME Department, but has moved to research. New programming in the geo-mechanical area is therefore not anticipated. The software developed to this point will continue to be available to instructors for use in modelling classes.

Structures Numerical Simulation Laboratory

Our aim is to create a computer capability that students and research personnel can employ for simulating experiments on actual structural systems. Such an effort requires one to integrate several sub-areas into a single operational unit. The sub areas are:

1. Structural mechanics and dynamics.
2. Deterministic numerical techniques for structural analysis.
3. Advanced graphics for displaying simulations.
4. Expert systems for interacting with the user for integrating all these capabilities.

During the first phases of this effort, individual packages were created to perform the various tasks. At this time, the main issue is the development of the interfaces between the individual units, and the expert system(s) required for combining them into an integral package.

Since the curtailment of programming activities in the geo-mechanics area, all our resources have been devoted to the successful completion of the numerical structural laboratory. As far as creating numerical codes for analyzing structural systems, the effort has been completed recently, and these codes are fully operational. Also, two expert systems were completed, one for the assessment of concrete dams and the second for the assessment of damaged, reinforced-concrete structures after they were subjected to severe dynamic loads. The creation of a user-friendly interface between the students and the numerical codes is well underway, and we anticipate that in the near future it will be possible to combine these two capabilities.

Future Plans

In the last year of this effort, we plan to create the necessary expert systems for controlling the entire package. For this purpose we will employ the latest version of the TI ''Personal Consultant Plus'', and to integrate all the IBM PC/AT and IBM Personal System/2 machines into one network. Also, we plan to maintain the DACU connection with the IBM 4341 mainframe, which will be used for large computational tasks (such as finite-element and/or finite-difference codes), in order to speed up large simulations. The IBM 4341 may also be used for large knowledge bases that could be required for the expert systems. The entire system will first be put in practice in the graduate-level course ''Dynamics II'' in Spring Quarter 1988. With further refinement, it will be used in teaching another graduate-level course, ''Behavior of Reinforced Concrete Structures I'', in Fall Quarter 1988.

Equipment

4 PS/2 Model 60s with VGA displays
4 PC/ATs with Enhanced Graphics displays
4 PC/ATs with Professional Graphics displays
1 PC/AT
12 Proprinters
12 Color plotters
4 Quietwriters
1 Color printer
1 Streaming tape drive
PC Network

Project Number: IT14

Enhancing the Graphics and Communications Capabilities of Education and Research Programs in the Theory of Condensed Matter Systems

J. Woods Halley
Department of Physics and Astronomy

Purpose

This project has two parts: the use of IBM microcomputers in the work of a computation-intensive theoretical research program based on molecular dynamics and Monte Carlo simulation of many body systems, and the development of educational software in the same field of physics research.

Progress

During 1986-87, we did not receive any further equipment from IBM, but we did receive a grant for non-IBM equipment, which permitted us to acquire a Marinco array processor for the PC/AT in 1985-86. During that year, we made the following progress in integrating and improving the system, using the AT in a variety of ways:

- Installation of Ethernet cards in four PC-compatible microcomputers, including the AT, in order to link directly to the Minnesota Supercomputer Institute and also to link the microcomputers together (though in a less-than-optimal way).

- Installation and software development for a Hewlett-Packard color plotter.

- Installation of a 20-megabyte hard disk and the Marinco array processor on the PC/AT. The hard disk was required to install the technical word processor TEX.

- Installation of a Hewlett-Packard laser printer on the PC/AT has now made standalone production of publication-quality manuscrits on this machine possible at a fraction of the former cost, both in staff time and in computer costs.

During the year, we have also installed DBase II and Lotus, for use in a new study of physics education in the United States. Graphics from the system have appeared in several research presentations by group members, including talks at the Materials Research Society meeting in Boston in December 1986, and at Argonne National Laboratory. In these presentations, we used color transparencies produced from polaroid photographs of the Professional Graphics Display screen to display time sequences of the Monte Carlo evolution of a model for dissolution of an alloy by an acid. Simpler graphics displays produced routinely by the system occur regularly in all the physics publications of the group. Testing and software development for the Marinco array processor is still in preliminary stages.

Future Plans

In the future, our main priorities in improving the effectiveness of the system are to improve the methods for coupling the microcomputers together, and to begin to do more of our simulations on the microcomputers themselves, using the array processor and improved software. The full utilization of Turbo Pascal, for instance, has made molecular dynamics possible on PCs in other laboratories. Both these priorities will require enlarged disk-storage capacity on the PC/AT and, since the capabilities of the power supply are not saturated, a hardware priority for next year is a second hard disk with its own power supply. If resources permit, we would also like to develop three-dimensional graphics capability, to produce animations of our molecular-dynamics simulations of chemical processes such as electron transfer at a metal surface.

Equipment

1 PC/AT with Professional Graphics display
1 Monochrome display
1 Color printer

Project Number: IT15

Combinatorics Laboratory

Dennis White
School of Mathematics

Purpose

The objective of this project is to produce software and provide hardware for a Combinatorics Laboratory. The software will be a package of programs designed to deal easily with common combinatorial objects: subsets, permutations, partitions, tableaux. It will provide visual aid to students who wish to study algorithms that manipulate these objects; and it willgive a programming environment for students to work on combinatorial problems.

Progress

Much of the work on the graphics and user-interface portions of the software has been completed, thanks mainly to the work of my programmer, Russell Young. Mr. Young designed and implemented a mouse- and-command-driven user interface. He has included many combinatorial algorithms that deal with subsets, permutations, integer partitions, set partitions, multisets, trees, and tableaux. These include listing, ranking, and unranking algorithms; and sophisticated transfer algorithms such as the Schensted correspondence and the Foata correspondence. He has written graphics programs for each of these objects. For example, permutations can be displayed as chessboard positions, in cycle form, or numerically. Partitions can be displayed in vector form, exponential form, or as Ferrers diagrams.

The development system we used was Turbo Pascal with MetaWindow and a Logitech mouse. The program was designed so that MetaWindow might eventually be replaced by MicroSoft Windows.

The laboratory itself has been set up in Vincent Hall 4, which was previously our terminal room for the time-sharing system.

The software was designed primarily for one course: Math 5-703, Constructive Combinatorics. This course is only offered in the spring. The rest of the time, the lab is used for other combinatorics courses, for graduate students and for the N.S.F. Teacher Renewal Project course in Discrete Mathematics.

The software has been used in Math 5-703 for the past two years. I have also given copies to several colleagues around the country, so we should get some useful feedback.

Future Plans

Mr. Young, unfortunately, has left the university. The future of the project depends upon finding (1) a quality programmer who can pick up where Mr. Young left off and (2) a mathematician with the interest and expertise to design the programming-environment portion of the project.

The programming effort remaining is the design and implementation of the combinatorial programming environment. The current software also needs tinkering. For instance, it could incorporate multiple windowing; there could be facility to provide statistics about various objects; and there could be on-line help.

At this time, work on the project has been suspended.

Equipment

2 PC/ATs with Enhanced Graphics displays
10 PC/XTs with Enhanced Graphics displays
12 Proprinters
PC Network

Project Number: IT16

Stochastic Modelling Lab

Larry Gray
Department of Mathematics

Purpose

The purpose of the "Stochastic Modelling Lab" is to provide researchers and advanced students with a library of software that demonstrates many different kinds of random phenomena. Included are real-time graphic displays of various stochastic processes (random dynamical systems), as well as demonstrations of some of the basic laws of probability theory. Researchers can use these tools to discover and analyze new or little-understood behavior in systems of current interest, and to test the plausibility of conjectures about such behavior. Students can use them as visual aids toward grasping sophisticated ideas.

Progress

The second year of this project has seen the development of several important pieces of the Stochastic Modelling Lab:

(i) A C language driver for the Professional Graphics Controller Card and Display. During the first year of the project, we worked with the Enhanced Graphics Adapter, but found that its capabilities were too limited for our needs. This year we received instead Professional Graphics Displays. Since we are working in the C language, and since the PGD works best when the software talks directly to its chip, we needed to write a library in C that includes all the graphics routines available for the PGD. This has been done.

We expect that there will be some minor updating of this library in the coming year, but it is already quite useful and complete. This display has greatly improved the rest of our software.

(ii) For students, we have developed displays of some basic stochastic processes, including Brownian motion, the Orstein-Uhlenbeck process, lattice random walks, and Poisson point processes, all in one and two dimensions, as well as Polya urn models with a variety of replacement schemes. We also have demonstrations of the convergence of empirical distribution functions and the solution to the Dirichlet problem in two dimensions. This second demonstration makes use of our Brownian motion display.

(iii) We have developed a test of random-number generators based on the range of 1-, 2-, and 3-dimensional random walk. This is the beginning of a package that will allow the user to test or compare a variety of random number generators. We have a growing library of routines that can be used to construct different generators.

(iv) A program called "Coral" depicts the random growth of an object that represents, for example, a piece of metal being formed by the random deposit of molecules coming out of a solution (it looks somewhat like a piece of coral). The shape formed appears to be what is called a "fractal". There is currently considerable interest in this process.

(v) Our most extensive package is one that displays a variety of "cellular automata". These are dynamical systems with a large number of interacting components. Each component is simple, as is the manner in which it interacts with other components, but the behavior of the whole system can be quite complex. The speed and color capabilities of the PGD are put to good use here. We have already discovered several interesting phenomena that were either previously unknown or at least not very widely known. This component of our lab has also been made fairly user-friendly and is simply a lot of fun to play with.

Future Plans

These are our main achievements so far. There is an almost unlimited number of ways in which we want to develop each of them further. During the coming year, we will be using the Stochastic Modelling Lab in conjunction with a first-year course in probability theory, and much of our time will be spent in that direction. We will also spend a lot of effort integrating the separate pieces, writing documentation for users, and other such chores. We have had the services of a programmer during the past summer, and he will continue with us during the coming academic year. He has been and will continue to be quite useful in helping us to put out finished products.

Equipment

4 PC/ATs with Professional Graphics displays
4 PC/ATs with Enhanced Graphics displays
6 Proprinters
2 Color printers

Project Number: IT17

A Model for Mathematicians to Impact Pre-Collegiate Mathematics

Thomas R. Berger and Harvey B. Keynes
School of Mathematics

Purpose

The second summer session of the NSF Teacher Renewal Project has just finished. This interim report describes activities using the IBM Woksape computers in support of this project. These activities can be divided into three categories: (1) data gathering and processing, (2) course development, and (3) direct instructional support. The project included activities in the summers of 1986 and 1987, plus activities during the 1986-87 academic year. Further, the project will continue with an academic-year seminar in 1987-88 and a third summer session in 1988.

Throughout the year, data were gathered and processed in the Talented Youth Mathematics Project (UMTYMP). The object is to evaluate the effectiveness of the UMTYMP and to monitor aggregate student progress and activities. The data will help to modify the program to best meet the needs of these very bright young people.

Materials development occurred during the 1986 and 1987 summer sessions, with materials testing taking place during the academic years. A special session during the 1987 summer session introduced teachers to materials being developed under a different NSF contract. The purpose of the NSF Teacher Renewal Project is to give mathematics teachers added mathematical knowledge, and to assist teachers in the development and testing of teacher-owned instructional materials.

During the year, teachers are supported through the Teacher Renewal Project via day-long seminars. These are highly valued because, not only do activities by project staff support teacher efforts, but also there is a strong internal teacher-to-teacher support network.

Progress

In the summer of 1986, thirty-six teachers developed materials in a computer science course under the direction of Professors Thomas Berger and Dennis White. Programming modules developed during this course were tested during the following year. Highlights of this course were programs to:

- solve several linear equations in several unknowns using rational arithmetic,
- differentiate and integrate polynomial functions, and
- graph functions.

During the 1986-87 academic year, teachers tested their materials and reported on their success. These reports generated interest in disseminating some of the materials.

During the spring of 1987, a computer bulletin board was set up for teachers to share materials from the project. This particular project was a failure. The reasons are not clear. The project has been abandoned temporarily.

During the summer of 1987, teachers continued development of teaching materials. Courses were taught on linear methods by Professor Thomas Berger and discrete mathematics by Professor Dennis White. In the former course, teachers undertook to move some the the earlier programs from IBM to Apple II computers, and to share these programs with more teachers. In the latter course, teachers developed additional programs supporting topics in a high-school discrete-mathematics course.

Professor Robert Devaney of Boston University has been developing (under NSF contract) high-school-level teaching materials centered on iteration of functions and chaotic dynamics. A small group of teachers from our project gathered to learn, develop, and test these materials in their classrooms. These teachers developed computer-graphics programs while learning topics from the dynamics of polynomial functions. They will class test these materials during the year and return in January to report their results.

Various evaluators have visited the Teacher Renewal Project and have always had high praise for the project. Professor Robert Davis of the Unversity of Illinois invited an article on the project to appear in the Journal of Mathematical Behavior. Teachers from the Project have been invited to participate in special sessions on mathematics in other states. Further, a special report will be given to the National Council of Teachers of Mathematics (NCTM) at their annual meeting in November.

Future Plans

Teachers will continue to meet several times during the year to develop materials and report on the testing of materials.

Developments will continue with teachers in the NSF Teacher Renewal Project. The summer session in 1988 will involve fewer teachers, and development and dissemination of materials will be far more intensive.

In the fall of 1987, development will commence on a highly interactive graphics-oriented calculus course for high-school students. This course will be developed for bright students in the University of Minnesota Talented Youth Mathematics Program. Materials will be shared with the School of Mathematics, where similar efforts to develop an undergraduate calculus course are underway.

Equipment

3 PC/ATs with monochrome displays
1 Professional Graphics display
1 PC convertible with printer
3 Color printers
1 Streaming tape drive

Project Number: IT18

Architectural Design Test Studios

Lee B. Anderson
School of Architecture and Landscape Architecture

Purpose

Our purpose is to develop innovative software and implement systems to facilitate interactive computer-aided architectural design and analysis. Our phase 2 equipment has arrived giving us a total of 33 networked IBM PC AT workstations with Professional Color Graphics and supporting color printers and plotters, and 1 IBM RT PC with the 5080 graphics system. These are placed in two architectural design studios where they are used by architecture students to assist in schematic design, analysis and presentation.

Progress

Facilities

The phase 2 equipment required that a second studio be built with the necessary electrical outlets, lighting, network channels and security alarm system. This has just been completed, and we will be starting regular classes in the new studio this Fall Quarter (87). In addition to the new studio, 3 secure offices were built adjoining the studio space for faculty and teaching assistants involved in the project. The offices, studios, and architecture microcomputer lab have cable channel between them and are networked together. The project has now grown to encompass one-fourth of the first floor of the Architecture Building.

Software

We have continued developing the design and analysis software started in phase 1. Major improvements include a new program interface, additional graphics database generation capabilities, interface with more digitizers and plotters, improved drawing speed and accuracy, alternate presentation formats, screen dump from the PGC to the color printer, interface to video, interface to CADWrite, and more extensive network support.

Classes

The phase 1 studio was used for four quarters last year, with student interest and enthusiasm continuing to be very high. Fall '86' concentrated on small- scale housing projects, including interior spaces. Winter '87' involved a medium-scale study center in Rome, and the Spring '87' project was a large- scale high-rise office building for downtown Minneapolis.

Students who have been in the studio often come back to borrow time on the "computer studio" machines to work on projects for other studios, and even come back after graduation to bring in work from their offices. This has led us to try to have two or three "hot seats" available for students who have taken the studio courses and want to come in and work on a temporary basis.

Public Relations

We continue to give a number of demonstrations to local and visiting architects, as well as those interested from IBM. The studio has been described in several publications, including one from IBM Rochester, and has been the subject of major articles in the *Technolog, Alumni Newsletter*, and *Minnesota Daily*. Student work has been shown in the Frederick Mann court of the Architecture Building, presented to the local Siggraph group, to architects at local AIA seminars, and nationally at A/E Systems. Work from the studio was also the subject of a presentation given at the annual IT Alumni meeting and dinner.

The ''computer studio'' was reviewed by the committee from our recent accreditation visit. They were very enthusiatic about the concept and our implementation, listing the project as a strength of the School of Architecture and Landscape Architecture.

Future Plans

Our progress in software development and need for creating and manipulating large data bases resulted in our being chosen for beta-site testing of the new IBM operating system OS/2. We will manage the project, which will also include components of the University Micro Computer Systems Group and support from the Woksape office.

We are looking forward to further development in several areas. The following are anticipated developments, with details depending on what we see happening in the design studios and the support that we are able to give each area:

1) *Building and modifying images based on a 3D image displayed on the screen* - Our present system builds a 3D database, but the interaction is through a 2D screen presentation. The new system will greatly improve our ability to use this tool for interactive design.
2) *Ability to develop and display larger data bases with OS/2* - Presently we are limited by the 640k limit to about 2400 polygons, or as few as 800 polygons if shadows are desired. This becomes a serious limitation as students develop expertise on the system. Additionally, present memory limitations limit the types of analysis that can be done with the data base.
3) *Increased interaction with video* - The combination of video and computer graphics is extremely useful for creating highly realistic images while limiting the time-consuming graphics data base development to only that which is necessary. It is also possible to create video animations that provide a much better means of understanding a design than a single image.
4) *Interactive analysis of the data base* - This can be achieved by passing an abstract of the data developed in the program to a spreadsheet, or to a program that we would write to perform analysis. An energy and cost-analysis program would be a typical example.

5) *Implementing an expert-systems approach to design assistance* - Although this is a very difficult subject, there are some areas, such as code checking, which could be done. Students in our advanced architectural CAD classes are now taking Prolog so that we can begin to work in this area.

6) *Using the RT PC for faster image generation and ray-tracing* - When the upgrade to the RT is available, we will be able to generate complex images about five times as fast as on the PC/AT, and provide the large memory required for required for voxal-based ray-tracing. Since this machine is on the studio network, students can transfer complex databases to the RT for fast

display or for high-quality ray-tracing with reflections and texture mapping.

7) *Physical modeling based on the graphics database* - An NC milling machine can be used to generate the surfaces created in the 3D data base. This subject also has possibilities in the area of Computer Integrated Manufacturing in Architecture.

8) *Interface to 2D drafting systems* - The present system of interfacing with CADWrite has not been practical because of the complexity of using CADWrite. Changing the interface file to the DXF file format would allow us to transfer to a wide variety of 2D CAD Drafting programs, many of which are more convenient to use. An interface to a drafting program makes further use of the data developed in the 3D modeling and provides a means of obtaining standard architectural working drawings.

Equipment

1 RT PC with advanced color display and tablet
1 RT PC with extended monochrome display
1 PS/2 Model 80 with 8514 display
1 PS/2 Model 60 with VGA display
1 PS/2 Model 50 with VGA display
32 PC/ATs with Professional Graphics displays and monochrome displays
17 Color printers
20 Color plotters
3 Proprinters
1 Streaming tape drive
PC Network

Project Number: IT19

Computer Programming Tutor

Maria Gini
Department of Computer Science

Purpose

The project is aimed at improving the process of learning the basic skills of computer programming. We expect, by improving the quality of the computing environment, to improve substantially the skills of our lower-division students and to prepare them better for upper-division courses.

More specifically, the idea is to create an interactive system to help beginners learn how to debug their Pascal programs and to identify what the student did and did not understand. The system will identify nonsyntactic bugs and help novices understand the misconception that caused the bugs. We have chosen Pascal because of the large number of students who learn Pascal in introductory courses.

Progress

We have spent a considerable amount of time in designing a system that satisfies our needs and is flexible enough to be useful. We have implemented most of the system and are in the process of debugging it. Four Master students and various undergraduate students contributed to its design and implementation. Two of the undergraduate students presented a paper on their work at a conference for undergraduate students in April 1987. Two Master theses related to this work will be completed in September 1987.

The availability of TI PC Scheme has helped the students taking the course CSci 3106. In that class we teach Scheme, but in the past, since we did not have any implementation of Scheme, we had to use Common Lisp instead. Using PC Scheme has meant a major improvement in the class. Since 3106 is a lower-division class taken by many students outside Computer Science, we have helped a large community.

We have developed software to enable us to use the PC network in a more effective way. For instance, we have developed a system of student accounts so that we can avoid random use of the systems and guarantee file space to authorized users. We have provided a communication line that enables the PC network to communicate with any computer reachable by phone. The PC network is also on the Arpa net. The mail program we have developed is in regular use and allows the exchange of electronic mail with any site on the Arpa net.

Publications:

Mohamed Bendelloul, ''A Flexible Matching Process to Diagnose Logical Errors in Pascal Programs'', Master Thesis, September 1987.

Ramdane Maamri, ''Understanding Logical Errors in Novice Programs'', Master Thesis, September 1987.

Future Plans

Testing a large and complex program takes a lot of time. We need to guarantee that the system is reliable and robust, because we do not want to confuse students with errors in a system that is supposed to help them in finding their errors. For this reason, we expect to spend a whole year in testing, beginning next year. The system should be ready for major demonstrations and for practical use at the end of the coming academic year.

We will continue working to provide better communication with other machines. We will continue using the PCs for 3106 and may start an experimental section of the Pascal class when we are ready to test our software.

Equipment

6 PC/ATs with Enhanced Graphics displays
2 PC/ATs
14 PC/XTs with Enhanced Graphics displays
1 Monochrome display
1 3812 Page Printer
1 Proprinter
1 Streaming tape drive
PC Network

Project Number: IT20

Software for Robot Programming

Maria Gini
Department of Computer Science

Purpose

This project will develop sophisticated software tools for robot programming using techniques and methods typical of artificial intelligence.

Progress

We have developed a variety of programs to simulate activities of robots. In particular, we have worked on simulation of navigation tasks for a mobile robot in a 2D environment. We have developed a method for representing the free space with generalized cylinders and for finding a path between two points. We have also developed a program in which a simulated robot explores an unknown 2D environment.

In addition, we have worked with the IBM robot in Mechanical Engineering (Woksape Project IT08) to design a robot system architecture that achieves reliable execution of industrial robot tasks. The system autonomously handles failures in robot programs performing parts manipulation and assembly. It starts with a robot program and generates an expanded form of the program, which monitors and controls the robot's operation in real-time. If a failure is detected during the robot's operation, information collected during execution is passed to a recovery process that handles the recovery. The recovery process analyzes the failure and plans the sequence of robot operations necessary to correct the failure and proceed with the robot's task. The recovery process passes the procedure back to the real-time system, which gets the robot going again.

We have also developed a prototype system that demonstrates the feasibility of this approach. The prototype system executes simple manipulation tasks and autonomously handles errors involving lost, dropped, missing, or obstructed parts. The present configuration of the system controls an IBM 7565 manufacturing manipulator. In addition, we have performed experiments of more complex tasks and recovery strategies on a simulated system.

The design of the error-recovery system incorporates three features of particular interest. First, the reasoning system and the real-time functions operate independently and execute on separate processors. Second, sensors are activated and monitored selectively, according to the robot's current action. Third, if the robot's task fails repeatedly, the system performs successive restarts and recoveries without ill effect.

The system uses separate processors for executing the reactive (or real-time) software components and for executing the reflective (or symbolic-reasoning) components of the system. This separation prevents time-critical software components from having to compete for computation time. It also allows us to choose a managing processor for its symbolic computation capabilities, rather than its real-time capabilities. Since the real-time executive is the only component that interacts with the robot continuously, a large-scale system could probably share a single reasoning system among several independent work cells, each with its own executive.

In the current implementation, the reasoning components reside on a Vax 11/780. Motion control and sensor filtering for the IBM 7565 are implemented on an IBM Series 1 minicomputer using the AML programming system. The real-time executive resides on an MC68000-based personal computer system, an Apple Macintosh.

Future Plans

We will continue working on the system for error detection and recovery, modifying the software to make the system more robust and flexible. We will also work on filtering sensor data to handle more types of operations.

We have plans to use one PC to control a mobile robot that we will acquire in the Fall of 1987. This will allow experiments with navigation, sensor processing, and real-time control. We will test with the real robot some of the algorithms developed in simulation.

Publications Related to the Project:

M. Gini and R. Smith, ''Monitoring Robot Actions for Error Detection and Recovery'', to appear in *Proc. of JPL Workshop on Space Telerobotics*, January 1987.

M. Gini, ''Symbolic and Qualitative Reasoning for Error Recovery in Robot Programs'' in U. Rembold and K. Hormann eds, *Languages for Sensor-Based Control in Robotics*, NATO ASI Series, Vol F29, Springer-Verlag, Berlin, West Germany, 1987, pp 147-167.

M. Gini, ''Automatic Error Detection and Recovery'', to appear in *Robot Technology and Applications*, (U. Rembold, ed.), M. Dekker, 1987.

R. Smith, ''An Autonomous System for Recovery from Object Manipulation Errors in Industrial Robot Tasks'', PhD Thesis, University of Minnesota, June 1987.

Equipment

1 PS/2 Model 80 with 8514 display
2 PC/ATs with Enhanced Graphics displays
1 Proprinter

Project Number: IT21

Development of a Mathematics Laboratory

Thomas R. Berger and Charles A. McCarthy
School of Mathematics

Purpose

Math Lab is an international effort to develop mathematics projects suitable for students studying science and engineering who have completed calculus. Small groups of students are intended to work together solving mathematical problems. The problems require self study and use some major software package. Projects range from series solutions of differential equations using MACSYMA to the structure and generation of the group of Rubik's cube using Cayley. Currently, there are more than a dozen projects being tested at various universities.

Progress

Late in the Fall of 1986, two IBM PC RTs were acquired for the development of Math Lab projects here at the University of Minnesota. Since the international software effort is being done on UNIX systems, these machines came equipped with AIX (IBM's implementation of Unix System V).

Problems have been encountered in getting some of the major software packages to run. Further, certain system software (such as uucp) has presented recurrent problems. Some of these problems stem from the early version of AIX and others stem from porting software developed on Berkeley UNIX to AIX. Linker and compiler problems combined with porting problems have significantly slowed development. These problems, along with limited development time, have made progress slower than anticipated.

Future Plans

During the summer of 1987, plans were revised to take computer difficulties into account. Development will be shared between PC RTs and University computing systems. Software will be moved to the RTs on a longer time scale. Further experiments are underway on both AIX and Berkeley 4.2 UNIX to see if a shift from AIX might facilitate development.

This fall, faculty will be solicited on a small scale to test individual Math Lab projects. It is hoped that one year from now a larger test can be conducted involving more students.

Equipment

2 RT PCs with Extended Mono Graphics displays
2 Proprinters
1 Streaming tape drive

Project Number: IT22

IBM VLSI Academic Program

Gerald Sobelman
Department of Electrical Engineering

Purpose

Very Large Scale Integration (VLSI) provides a technological opportunity for designing and implementing complex digital systems on a single silicon chip that would otherwise occupy complete circuit boards. In order to successfully carry out a VLSI design project, one must have a set of computer-aided design (CAD) tools, a reliable manufacturing environment, and suitable testing procedures. IBM Corporation, through its VLSI Academic Program (Manassas, VA), is providing precisely this type of support to four participating universities, including the University of Minnesota. This program enables students to participate in a realistic VLSI design experience, all the way from initial design description to final testing.

Many universities offer various types of courses in VLSI design, some of which include actual VLSI design experience. This design experience is normally obtained through use of the federally-funded chip-design facility known as MOSIS, administered by Information Sciences Institute of the University of Southern California. This facility contracts with commercial semiconductor fabrication houses and offers a variety of technology options. Universities that submit designs through this service must, however, assemble their own sets of CAD tools, and develop and apply their own design and testing methodologies. While this facility offers the chance to explore a wide range of design alternatives, it requires a considerable amount of sophistication on the part of the users. Thus, it is not entirely satisfactory as a student's first exposure to VLSI design.

The IBM VLSI Academic Program represents a truly unique educational resource. In contrast to the MOSIS program, IBM has supplied us with a complete set of CAD software developed explicitly to support IBM's fabrication environment. In addition, the design process is greatly enhanced by the use of a library of functional modules that comes as part of the system. A student uses these modules, which have been verified by IBM for correctness, as basic building blocks. Another element of the design system is a well-developed testing discipline that ensures that manufactured chips can be sufficiently checked for proper functionality.

Progress

The Electrical Engineering course sequence 5574-5575 (VLSI Design Laboratory), offered during the Winter and Spring Quarters of the 1986-87 academic year, was based entirely on the Woksape-sponsored IBM VLSI Academic Program. Five XT/286 workstations and other required communications hardware had been installed in our departmental Woksape Lab just prior to the start of the Winter Quarter. After considerable developmental work by key individuals from St. Paul Computing Services (SPCS), Project Woksape, the local IBM field-service office, and IBM Manassas, our VLSI design system became fully operational in time for use by the students. In our current configuration, students enter their designs directly onto workstations, using a menu-driven graphical format. Then, this design information is sent electronically to the SPCS IBM 4381 mainframe, where large simulation and chip-layout programs are run. Finally, the students can access the results of these mainframe programs on their workstations and make modifications in their designs as required.

In this initial offering of the course sequence, eighteen graduate-level Electrical Engineering students worked in teams of two persons each to produce nine complete chip designs. IBM supported our efforts in various ways throughout the two-quarter period. For example, technical experts from IBM facilities in Manassas and Rochester, Minnesota gave particularly informative presentations to the class on several aspects of VLSI design.

At the end of Spring Quarter, 1987, the designs were sent via Bitnet to IBM Manassas, where they were checked for adherence to design rules. In addition, IBM Manassas generated large plots of the chips for distribution back to the student designers. Our chip-design projects were highlighted in the July, 1987 issue of a newsletter about the program produced by the group at IBM Manassas. In addition, one of the projects was sufficiently interesting from a research point of view that a paper describing this design was presented at an international conference. All parties involved agreed that this first offering of the course had been a success.

The same course sequence was offered again during the Winter and Spring Quarters of the 1987-88 academic year. This second offering of the course sequence focused on the implementation of some novel architectures for digital signal processing applications. Two graduate students who were veterans of the 1986-87 course sequence assisted as part of their Master's degree programs, by developing some promising new architectures that wereimplemented by the second group of students.

Future Plans

Some new CAD software packages have been obtained which also run on the workstations. These new packages provide additional capabilities for creating advanced VLSI designs. We plan to use these systems in our senior-level design project course, EE 5450.

Equipment

5 PC/XTs with Enhanced Graphics displays
5 Proprinters
1 Color plotter
PC Network

Project Number: IT23

Modelling and Visualization of Three-Dimensional Crustal Features in Stratigraphy and Structural Geology

C. Paola, C. Teyssier, K. Kleinspehn
Department of Geology and Geophysics

Purpose

The overall purpose of this project is to develop novel programs to help geology students visualize complex three-dimensional structures in the Earth and to understand how their forms are controlled by the forces that produce them. Specifically, we are focusing on two areas: sedimentary geology and structural geology. In sedimentary geology, various combinations of surficial processes (e.g., wind, rivers, ocean currents) deposit sediment on the Earth's surface, mainly in areas where the crust is subsiding. Many practical problems involve predicting the size and shape of bodies of some particular sediment type (usually sand) within a given deposit. The sedimentary-geology section of the project involves writing programs that allow students to vary interactively some of the main parameters that determine deposit and/or sand-body geometry (e.g., rate of subsidence, sea level, current strength) and to see the results in the form of a three-dimensional model.

In structural geology, the emphasis is on deformation of the crust under applied stresses, often the result of interactions between tectonic plates. These deformations can create three-dimensional features of great complexity (e.g., refolded folds). Their geometry depends on, among other things, the geometry of the applied stresses and the mechanical properties of the rocks being stressed. Again, our approach is to let students vary the main governing parameters interactively in a computing environment that allows them to see the results immediately (more or less) and in three dimensions.

Progress

One PC/RT system with 5080 graphics processor was delivered to the Department of Geology and Geophysics in September, 1986. Since there is no high-level 3D graphics interface that we are aware of that is geared towards displaying images like those with which we are working, we decided to use IBM's implementation of the PHIGS standard (IBM graPHIGS) for the display sections of our programs. This has proven to be a formidable task: PHIGS provides a great deal of control but, as usual, the tradeoff is that coding even relatively simple displays is very complex. Thus, we scaled back our ambitions a bit in the first year and decided to focus on PHIGS display programs that students could use easily without doing any programming. This effort was a success: We have been using and developing a software package in GEOL 5653, Basin Analysis. In that class, students were given realistic well data (cores, electric logs, etc.) and asked to provide a three-dimensional map of the stratigraphic units in the wells. The display of such maps is something for which PHIGS is well-suited. The students were able to produce 3D images of the stratigraphy in the basin and view them from any angle, in real time, by manipulating dials attached to the 5080. This provides a picture of the geometry of the strata that would have been very hard to obtain using conventional, two-dimensional techniques.

The IBM RT PC workstation has been used in the Structural Geology laboratory (GEOL 5201) for the last two years. The emphasis has been on the mechanical aspect of deformation. The two laboratory sessions (4 hours total) that address this question are aimed at isolating the effects of different elastic parameters (such as Poisson's ratio or Young's modulus) on the flexural deformation of an elastic plate. After studying the elastic properties, the student then addresses the effect of boundary conditions (such as the thickness of the plate or the load imposed on it) in the geologic cases described below.

The first exercise is an experiment that simulates the instantaneous load produced by the geologic emplacement of a volcanic seamount. The second experiment is concerned with the deformation of the crust just following a caldera collapse or the melting of an ice sheet. These simple cases illustrate the fact that more complicated rheological properties have to be adopted in order to account for the time evolution of geological phenomena (time-dependent rheology of the mantle, for instance). Realistic results are obtained in certain cases, however (ice sheet), by using elastic models.

Future Plans

Our main goal during the coming year is to continue our original plan of providing students in at least three courses (Sedimentology, Structural Geology, and Basin Analysis) with interactive-modelling labs as described in the first section, using the RT/5080 system. In addition, we are encouraging other faculty members to use 3D graphics in their classes. In particular, PHIGS is suited for displaying four-member phase diagrams common in igneous and metamorphic petrology.

Equipment

In 1989, this project was discontinued and the equipment allocated to Project Number IT18.

Project Number: IT24

A Microcomputer-Based, Real-Time, Three-Dimensional Machine Vision System

Steven K. Case
Department of Electrical Engineering

This project has been terminated.

Project Number: IT25

Microcomputer Yield-Optimization Software

Rolf Schaumann
Department of Electrical Engineering

Purpose

The intent of the proposed work was to develop a design-centering package for student and faculty use that can be run *inexpensively* on a personal computer. Design-centering deals with the very practical problem of maximizing *yield* in circuit or system design under the constraint of components that have *finite tolerances.* The goal for this project is to use the kernel of an existing design-centering program (DECE), link it with an existing circuit simulator (SPICE), and make the package available and easy to use on a personal computer. This pilot program should permit testing whether the availability of a design-centering software package on a personal computer will facilitate teaching the concepts of tolerance and yield, and their interrelation in engineering design to both undergraduate and graduate students in practical, hands-on, inexpensive ways.

Progress

Having received our hardware only in August, 1987 has held up progress to the final state of the software considerably. Nevertheless, two programmers worked over the summer on an IBM PC/AT to arrange for the needed interface of SPICE and our design-centering program DECE. To this end, a commercial version of SPICE (in FORTRAN) was loaded on the PC, analyzed, and modified as appropriate to permit direct interfacing with DECE. The task proved more difficult than anticipated, mainly due to memory limitations on our AT; but in an approximate way, this goal was accomplished some while ago. Our initial intent, to let the two programs simply communicate by data exchange via array transfer through their own I/O routines, had to be abandoned because of excessive run-time limitations. Instead, we had to modify the source code to achieve direct transfer of data while bypassing the programs' I/O. We are now in the process of adapting/tuning the program to the new hardware.

Current status: We have simulated a few sample designs with known results to test the program. At this time, the total program (DECE-SPICE combination) works fine, with the exception of a couple of minor and well-identified bugs that should be cleared up in about a week. The main, somewhat expected, difficulty with the software is extensive run time: The computer will run for hours to optimize realistic circuits.

Future Plans

Apart from bug-fixing, our remaining job consists of making the software useful for instruction. That is, we need to:

1) Create easy-to-understand I/O routines. Currently the input requirements are largely the same as those of SPICE; output is as in SPICE via tables or line printer. A friendlier circuit input will be sought.

2) Write a user manual suitable for users who are oriented to electronic circuits, but who are not experts.

Equipment

1 PS/2 Model 50 with VGA display
1 Streaming tape drive
1 Proprinter
1 Color plotter

Project Number: IT26

High-Speed Real-Time Computer-Control Unit for Multi-Parameter Manufacturing Systems

H. Kazerooni
Department of Mechanical Engineering

Purpose

One of the most prominent applications of microcomputers is in real-time control of engineering systems, which is quite common in industries and universities. Many commercial software packages for real-time control of one-parameter systems have been developed. Among these, the bang-bang controller for temperature control and PID servo controller are quite well-known. Multi-parameter systems, however, need more computation power. The more complex the system is, the more computation is needed to develop an appropriate output for control of the system. Thus, the limiting factor in real-time control of processes is the computation time. If a computer cannot keep up with the dynamics of the system, errors and eventual instability of the system will occur. This project concerns an innovative approach to develop a high-speed computing environment using a workstation comprised of two PC/ATs and one NCUBE parallel processor for real-time control of multi-variable systems.

While one of the PC/AT's is being used solely for data acquisition and I/O operations, the other hosts the NCUBE parallel processor board via UNIX operating system. Presently, there are four electromechanical systems in the Motion Control Laboratory of the Mechanical Engineering Department (room 359) that are being controlled with Woksape computers.

In addition to the research need for high-speed computation, the following classes use the unit for homework, experiments, and term projects:

ME8280, Multi-variable Control I
ME8281, Multi-variable Control II
ME5283, Industrial Instrumentation and Automatic Control

Progress

Described below are the four target systems being controlled with the Woksape computers. These systems are tools for practical evaluation of the performance of the workstation in different regions.

1. *Automated Deburring:* The dominant variables in deburring three-dimensional edges of industrial parts are the contact forces, velocities, and position of the deburring tool. The objective is to control the trajectory (position and the velocity) of the tool along the edge of the parts, while the forces are under control to prevent chattering. A two-dimensional automated deburring system has been developed in the Mechanical Engineering Department to develop adaptive control methodologies to automate deburring processes. The system consists of an XY-table to maneuver the part, a robot to move the tool, and a computer to control the process. The contact force, the position, and the velocity of the tool in two dimensions are measured by the computer. After the data acquisition is completed (four digital and two analog inputs), the control

algorithm is executed and the appropriate signals (total of two analog signals) are sent out to maneuver the tool along the edge of the part. The entire cycle-time of the above operation is 4ms with one PC/AT.

2. *Active End-effector:* We have built an active end-effector, which can be used with any robot to compensate for robot-position uncertainties and vibrations. Six variables are measured by the computer, and two signals are sent to the actuators of the end-effector for compensation of robot vibration. The control algorithm consists of the execution of a six-input, two-output filter, in addition to I/O operation. The sampling time is about six miliseconds with one PC/AT.

3. *Wide Bandwidth Tool Positioning Systems:* In this project, we are investigating the development of the high-frequency motion control of a cutting tool via a computer. A servo system controls the motion of the tool at a particular frequency. This frequency can be chosen to be up to 40 hertz. The PC/AT has been used for development of the real time control algorithms. The position and velocity of the motor are measured by the computer. This system is attractive in machine-tool industry for generation of the non-circular cross section cylinder.

4. *Minnesota Robot:* We have also constructed a robot manipulator for high-speed assembly. The robot has a new architecture that is attractive from the stand point of manufacturing operations. We have not interfaced the robot with the computer yet, although several software codes have been written for robot control. Joint angles and the joint-angle rates will be measured by the computer, and the appropriate signals will be sent to three actuators of the robot.

Proposed Methodology

The final architecture is as follows: One PC/AT is used for data acquisition and one, which hosts the NCUBE board, for computation. Both units are instrumented with parallel I/O boards and can communicate with one another via these I/O boards. Unit one has also been instrumented with an I/O board for communication with the physical system only. The NCUBE board has 4 nodes and a PC-AT bus interface. While unit 2 is computing the control action, unit 1 is sending out the previously computed output and collecting new data.

To accomplish these operations, we have completed the following tasks:

1. Control programs have been written for the first three projects in Fortran, C, and Assembly. The first three systems have been interfaced with one computer (an AT without the NCUBE). This phase of the project is only for verifying that communication and control of the process and one processor is stable. Then, we will expand this to using parallel processors.

2. Four major software programs have been developed in assembly language to allow the PC/AT/NCUBE to communicate with the outside world. These software programs are:

   a. Analog to Digital Conversion
   b. Digital to Analog Conversion
   c. Digital Output
   d. Digital Input

The I/O boards are from Data Translation Company, and no software program is available to read these boards in a UNIX environment.

3. The PC/AT/NCUBE has been tested very carefully by running a variety of experiments. The test involves the incorporation of the PC/AT/NCUBE in a loop. In one experiment, we interfaced the computer with an analog controller (a proportional and derivative controller made by MOOG company). We simulated the dynamic behavior of an unstable hydraulic actuator in the computer. The simulated output velocity was fed to the analog controller and the control signal from the analog controller passed to the computer as the input to the simulated actuator. The communication was successful, and the analog board stabilized the simulated unstable hydraulic actuator.

Future Plans

1. Further development of the C-callable and Fortran-callable subroutines allowing for communication between the computers and boards.

2. Interfacing the two PC/ATs together via the two I/O boards. The major problem with this step is the timing management between the two computers.

3. Evaluation of the performance of each target engineering system when using the system of two PC/ATs and the NCUBE board in terms of how fast one can control a particular process with the proposed computer architecture.

4. Studying I/O time vs. computation time. Accumulation of the I/O time and the computation time in a cycle is the minimum of the all possible configurations of using the nodes.

Equipment

2 PC/ATs with Professional Graphics displays
1 PC/AT with Enhanced Graphics display
3 Proprinters
2 VGA displays

Project Number: IT27

Computer-Aided Teaching in Electromagnetics

M. Riaz
Department of Electrical Engineering

Purpose

The project is designed to develop a series of computer-aided design experiments based on finite-element methods (FEM) for use in teaching design and analysis of typical generic electrical engineering structures or components such as transmission lines, transformers, actuators, electric machines, and magnetic recording heads. The experiment will exploit specific and modified FEM software packages in electromagnetics for use on IBM personal computers.

Progress

The 3 IBM PC/PS/2's requested for phase 1 of the project arrived at the end of August. An IBM PC-XT286 was used during Spring Quarter 1987 to test and explore the capabilities of several FEM packages. Based on comparisons, it was decided to adopt the flexible and powerful approach used by the Ansoft Corporation. Therefore, six computer packages were acquired for use on ten IBM machines to study field problems in electrostatics, magnetostatics (both linear and nonlinear) in 2-D planar and axisymmetric geometries. These programs have just been installed on the new PS/2 computers.

Future Plans

The finite-element method will be applied to obtain the parameters of single and three-phase transmission lines.

A series of simple, computer-based experiments will be developed during Fall Quarter 1987 to examine static field distributions in 2-D for simple geometries such as a parallel-plate capacitor, slot leakages in machines, conductors and dielectrics in uniform external fields, forces on conductors, and magnetic structures. The object of these experiments is to supplement the classroom teaching of electromagnetic field theory.

Equipment

3 PS/2 Model 50s with VGA displays
1 PC/XT with Enhanced Graphics display
3 Proprinters
3 Color plotters

Project Number: IT28

A NETBIOS-Based Gateway to Internet

Neta Amit
Department of Computer Science

Computer networks, both Wide Area (WAN) and Local Area (LAN), bridge physical gaps between remote sites, for better economy, (e.g., access to exotic hardware) and better communications.

In the construction of any network, a crude distinction can be made between the network end, which is responsible for actual transmission of bits from source to destination, and the machine end, which defines the type of service available to users. These roughly correspond to layers 1-3 and 4-5 respectively, in the well known ISO-OSI model of 7 network layers (layers 6-7 are application-oriented). The relation between the machine end and the network end is many-many, i.e. many machine ends can be built on top of the same network end, and the same machine end can be constructed on various network ends. A good example is the IP/TCP machine-end protocol, which has been implemented on various WANs and LANs.

When two networks are connected, services available on one end need to be translated to equivalent services available on the other end, through a gateway. This is a relatively simple matter when both ends match, since minimal translation is required. This is the case with Ethernet (LAN) connected to the Arpanet (WAN), since they both speak IP/TCP. As a result, all the major services are supported: Mail, File Transfer (FTP), and Remote Login (Telnet). It is much harder when the ends don't match, for example when Bitnet (WAN) is relayed to Arpanet. It is not surprising that, in this case, only Mail services are supported.

All the subnets and stand-alone computers in the Computer Science Department at the University of Minnesota run the IP/TCP protocol, with one exception. The IBM-donated Woksape subnet runs an IBM network protocol, PC-LAN. This puts PC-LAN users in relative isolation. In support of other Woksape projects, ours started as an attempt to remedy the situation in a cost-effective way.

As indicated above, since IP/TCP and PC-LAN do not match, there is need for translation of services from one network to the other. Our first priority was to provide Mail services and link Woksape PC-LAN users with the rest of the Arpanet world. This part is now nearly complete, with a user interface similar to Unix's Mail program. The additional hardware was minimal -- one Ethernet card (3Com Ether-link) inserted into the Gateway PC. The software has four parts: PC-LAN Client and Server, Gateway, and IP/TCP. The last part was ported from MIT. This work was accomplished as part of Woksape project IT20.

The higher level machine end communicates with the lower level network end via a set of system calls (or primitives, or hooks). One important set of hooks is called NETBIOS, and several machine ends, including PC-LAN, are built on top of NETBIOS. Our goal is to implement the machine-end IP/TCP directly on top of NETBIOS. We will then have a much closer match between the Computer Science Ethernet and the Woksape subnet, and be able to offer FTP and Telnet, as well as Mail (which will be re-implemented). Furthermore, the resulting IP/TCP and services will be portable to any NETBIOS environment.

Equipment

TCP/IP Software for IBM PCs

Project Number: IT29

Computer-Aided Teaching in Electric Energy Systems

Vernon D. Albertson and Ned Mohan
Department of Electrical Engineering

Purpose

The objective of this project was to develop computer programs to complement the teaching of electric-energy-system theory, design, and analysis. The programs developed will be used in demonstrations and laboratory exercises for students in the simulation and design of electric-energy systems, or specific segments of energy systems, and can also be used for research. Areas of applications include electric and magnetic field effects of transmission lines, overvoltages due to switching transients, power flow and voltage profile control, determination of short-circuit currents and system voltages during unsymmetrical faults, control of interconnected generators and system stability, frequency-dependent and traveling-wave phenomena, effects of harmonics on system equipment and loads, ac/dc conversion and inversion for high voltage dc transmission, and control of alternative energy sources interfaced with power grids.

Progress

The project involved the adaptation of the PC version of the large Electromagnetic Transients program (EMTP) for use in teaching and research. The PC version of the EMTP is called the Alternative Transients Program (ATP), and is available in the public domain at minimal cost.

The ATP is an exceptionally versatile and complete computer program for modeling and solving electric-energy-systems problems but, unfortunately, has an extremely large and complex user's manual. The complexity of the normal user's manual makes it prohibitive to use the ATP as an undergraduate teaching aid in classes, and difficult to acquire proficiency with the program even in 3 to 6 months for graduate students in advanced courses or research. Thus, a major goal of the project was to write a condensed user's manual with relatively elementary examples, to allow undergraduate and graduate students to quickly acquire familiarity with the program. It is then much easier for students to progress to the more difficult analytical or design levels after confidence is gained with the simpler example problems and variations.

We wrote a condensed user's manual for the ATP, called the ''ATP Primer''. The manual contains an example of determining the transients in a series RLC circuit, as well as an example that determines the electrical parameters of a high-voltage transmission line from conductor data and line-geometry data.

Future Plans

Additional examples will be developed for inclusion in the condensed user's manual as the program becomes more widely used in senior-level and graduate courses. It is also hoped that modifications can be made to the ATP program to make it more user-friendly and interactive, within the storage and memory capabilities of microcomputers.

Equipment

1 PS/2 Model 60 with 8514 display
1 Proprinter
1 Color Plotter

Project Number: IT30

Automatic Test Case Generation Tool

W.T. Tsai, M.E. Fayad, D. Volovik,
T.F. Keefe
Department of Computer Science

Purpose and Progress

We developed a method and a complete software system to automatically generate test cases for relational-algebra specifications expressed as queries. Since black-box testing requires test cases to be generated from specification alone, it is impossible to completely generate test cases automatically for arbitrary specifications. We thus restrict the specifications to be written entirely in terms of relational-algebra queries or expressions.

Testing is usually done very late in the development cycle; most of the large errors discovered in specifications after design and implementation stages are very expensive and time-consuming to correct -- *Testing specifications allows early error detection.*

- Test cases are usually generated manually. We generate test cases automatically.

- Test cases are generated from code. We generate test cases from specification.

- Testing usually leads to difficult, time-consuming, and expensive procedures. Our method explores the idea of specification testing, which allows early error detection and reduces time and cost for the testing process.

Besides these advantages, we can compare our method with random mutation testing from code.

Automatic Test Case Generation Method

Given a module of a subsystem that is specified by a relational algebra query, we generate a sample data base and an answer to a query to test the specification.

Given an implementation (code) of a module of a subsystem that is specified by a relational-algebra query, we generate a data base and an answer to a query to test the code.

System Architecture

The architecture of the system is illustrated by Figure 30-1 on the following page.

Random Mutation Testing

Testing is random in two senses:

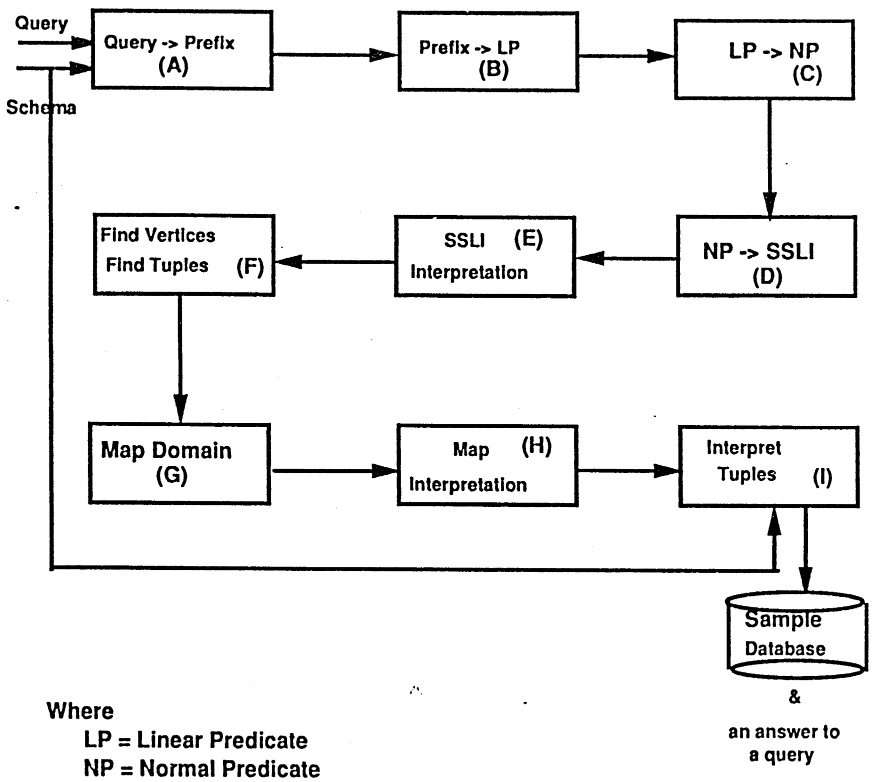
- Random data are generated.
- Mutation test cases are selected randomly.

A table summarizing the test process is shown in Figure 30-2 on the following page.

Mutation testing is used to compare and show the advantage of our method for specification testing over the method of mutation testing and any other methods used for testing code.

The table in Figure 30-2 shows what is mutated and how. The mutation testing is demonstrated on five queries (process query programs written in C) and three to four random data bases with different ranges. We end up with about 17 process-query programs that are mutated at least 15 times each.

Structure Chart for Automatic Test Case Generation Tool



Where
LP = Linear Predicate
NP = Normal Predicate
SSLI = Set of systems linear inequalities

Figure 30-1. System Architecture

What is mutated ?		#	How is it mutated ?	Comments
Condition	Values	--	Random	-5 / +15
	Sign (ineq)	--	Random	<, <=, =, !=, >=, > 1, 2, 3, 4, 5, 6
	& and ||	--	Change	
	Variable.names	--	Next occur and different or previous occur and different	
Loop	Initial	1	Random	0, 20
	Sign (ineq)	2	Random	<, <=, =, !=, >=, > 1, 2, 3, 4, 5, 6
	Increment	3	Flip ++	

Figure 30-2. Random Mutation Testing

Automatic Test Case Generation Tool

This tool, illustrated in Figure 30-3 below, has a menu-like user interface in which the main menu has access to three different submenus:

1 *Tool Chart*
2. *Generic Query Driver* -- allows the user to enter his or her own relational-algebra specification (query), generate code and check the intermediate results and final result.
3. *Select Query Menus* -- allows the user to select one query out of five and automatically open a new submenu that allows the user to process the query, check the result, go through the mutation testing selecting his own mutation test cases, and check the result. It also allows the user to generate his or her own random data bases for the mutation testing.

Systems: We developed an automatic Test Case Generation tool on the IBM PS/2 Model 80.

Languages: Turbo Prolog, Turbo Pascal, and C.

Conclusions

In this report, we describe a complete software system (a method and an implementation) for automatic test-case generation from relational-algebra specifications, in contrast to the more commonly-used random-mutation testing method. The major components of this system are:

1. The mapping rules from relational-algebra queries to linear predicates;
2. The translation from linear predicates to a set of systems of linear inequalities (SSLI);
3. SSLI interpretation;
4. The use of SSLI to generate a complete test case, inputs, and expected outputs from the queries;
5. User interface;
6. A large number of mutated C programs

Equipment

1 PS/2 Model 80 with 8514 display
1 Proprinter

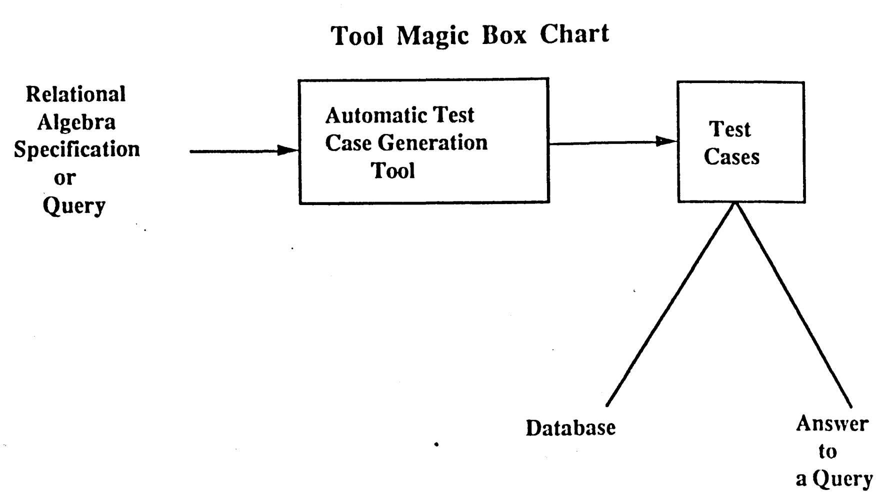


Figure 30-3. Automatic Test Case Generation Tool

Project Number: IT31

Rating of Highway Bridges

Roberto T. Leon and
Theodore V. Galambos
Department of Civil and Mineral Engineering

No report was submitted for this project.

Equipment

1 PS/2 Model 80 with 8514 display
1 PC/AT
1 Proprinter
1 Color plotter

Project Number: IT32

Computer Access for Disabled Students

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Department of Computer Science
Sue Kroeger
Office for Students with Disabilities

Purpose

This program, funded in March of 1988, arose from cooperative planning among four University units and one community agency. The University units involved are the Institute of Technology, Office for Students with Disabilities, Department of Independent Study, and General College. The community agency involved is the Courage Center, a rehabilitation center in Golden Valley.

There are two primary purposes of this project. First, we will develop "accessible computer stations" that will open educational opportunities to disabled students at the University of Minnesota. We aim to provide the tools necessary for an otherwise qualified disabled student to have full access to the University's computing services, thereby enabling the student to complete university course work. These accessible computer stations will be located at the Courage Center and in the Department of Computer Science at the University.

Second, we propose developing an Independent Study offering of Computer Science 3001, "Computers and Society." This course will be offered to disabled students via the accessible computer stations. In addition to giving students the opportunity to earn college credits, the course will provide a means to test the value of such computer-based aids in achieving academic goals.

Progress

In April, 1989, an accessible computer station was installed in the Computer Science Instructional Lab at the University of Minnesota. This computer station was demonstrated to the public during the week of April 24. As of May, 1989, there are seven persons using the station to complete a variety of tasks. The needs being served are primarily those of vision and motor impairments, and the tasks performed include word processing, spreadsheet analysis, and computer programming. The equipment is available to all members of the University community.

The Independent Study offering, Computer Science 3001, is under development and will be available in Fall, 1989. This will provide further academic opportunities for the users, as well as another means of testing the equipment's success.

The Office for Students with Disabilities has identified 150 current students who could benefit from accessible computer stations. The need for such equipment has also been expressed among the University's faculty and staff. Demand for accessible computer stations on campus is expected to increase as the community becomes aware that such services are available, and as the trend toward mainstreaming the disabled continues.

To meet the demand for accessible computer stations on campus, we are pursuing three courses of action:

First, we will make more accessible hardware available by installing a second accessible computer station on campus in the next year, and by installing an off-campus station at the Courage Center.

Second, we will propose continued staff support in the following areas:

1 installing and maintaining accessible equipment;
2. assessing and training potential users of the stations;
3. disseminating information about accessible computer stations within the University; and
4. maintaining contact with appropriate city, state, national, and international organizations to keep abreast of the current technology in this field.

Third, the development and implementation of the Independent Study offering will provide information on how accessible computers can be incorporated into academic course work. The knowledge gained from this experience will provide guidelines for how all courses can be made accessible to people using adaptive equipment.

Equipment

2 IBM PC/ATs with Enhanced Graphics displays
2 PC Serial Aid, alternative keyboard interfaces
2 TASH Mini Keyboards
2 Unicorn Expanded Keyboards
2 TSI Vista, large-print computer-screen output devices
1 TSI Advantage, CCTV print enlarger
1 VTek MBOSS-35, braille printer
1 VTek Braille Display Processor, braille computer screen output device
2 Artic Business Vision, speech output devices for the computer

In addition, we are using a variety of assistive computer software.

Law School

Impact of Project Woksape on the Law School

Betsy Baker, Assistant Dean

Project Woksape is allowing the Law School to expand on its leadership in the use of interactive video (IAV) technology for innovative instruction. It is fitting that the first and single Woksape project granted to the Law School involves IAV, since law professors from around the country and faculty members from many disciplines have consulted with Professor Steve Simon of the Law School Clinic for his expertise in developing IAV exercises.

With the Law School's Woksape grant, Professor Simon and the Law School Clinic are developing IAV exercises to teach the complicated skills of personal interaction that are involved in client interviewing. This application of IAV brings new dimensions to an area of skills training that has traditionally been taught using student simulations or non-interactive viewing of videotaped interviews. Neither of the older methods allows for satisfactory instruction in handling complicated factual circumstances. Use of IAV will allow the students to respond interactively to a branched series of questions involving both factual questions and issues of substantive law.

The Law School Clinic has traditionally combined practical skills training with instruction in substantive law. By being introduced to new computer applications in the Law School Clinic, students learn that use of these technologies will have very practical applications in the actual practice of law. Woksape is promoting not only the use of computers in an academic, instructional setting, but encouraging the continued development of new applications by practicing lawyers as well.

Increased use of IAV instruction will also promote student use of the non-IAV computer instruction available in the Law School, by increasing general familiarity with and appreciation for the computer as an academic aid. The Law School is home to CALI, the Center for Computer Assisted Legal Instruction. More than 100 law schools around the country belong to CALI, receiving its software and promoting authorship of new CALI exercises. CALI provides instructional software used in class assignments, as a supplement to class discussion, and as a tool for reviewing topics covered in the classroom. As CALI expands its use of IAV, all member law schools will adopt the technology more widely.

Project Number: LAW01

Client Interviewing

Stephen M. Simon
Law School

Purpose

Client interviewing is fundamental to the effective and efficient practice of law, yet is difficult and time-consuming to teach using existing teaching methods. The current method of teaching client interviewing involves students conducting a simulated interview with each other, then receiving faculty critiques on the quality of their performance. Teaching client interviewing with interactive video (IAV) allows students to practice the skills in a lifelike situation. IAV can present students with complex interviewing situations and then give immediate feedback on how well they are performing the skills and understanding the concepts involved in interviewing. This complexity is difficult to obtain in live simulated interviews using law students as interview subjects. While IAV will not totally replace faculty/student interaction in the teaching of this and other skills, it will allow the student to spend much more time actually performing the skill, because it breaks the time-limit barrier that exists when a faculty member must observe every live-interview simulation. The project will be one of the first IAV client-interviewing exercises produced anywhere in the country and could be used in law schools throughout the country.

Progress

During the 1988-1989 year, we developed four client-interview exercises in the areas of criminal law, family law, personal-injury law, and immigration law. These four areas represent four of the largest and most frequently-occurring types of legal problems that an attorney is likely to deal with. In each area we identified key legal and interview process issues. A basic instructional design was developed with help from the staff of Project Assist. Scripts incorporating the legal and interview process issues have been written and are being edited and refined.

The Law School selected the University of Minnesota Media Resources Department to do videotape production. As originally proposed, amateur actors were going to be used for this project. Media Resources recommended that professional actors be used to increase the quality of the project and agreed to contribute approximately $6,000 for professional actors' salaries. Media Resources has been conducting interviews and screen tests of professional actors to select the actors for this project. They also recommended that the interviews be videotaped in a real law office. We have identified a suitable office and obtained permission for its use. Videotape production of the four exercise areas is scheduled for the first part of June.

Future Plans

After the interview exercises are videotaped, we will edit them at Media Resources in June and July. When editing is complete, the laser videodisc will be manufactured. This should take place in late summer or early fall. When the disk is completed, text drafting and programming will begin. This process will be time-consuming, but should be completed by the end of 1989.

Equipment

1 PC/XT with Enhanced Graphics display

Medical School

Impact of Project Woksape on the Medical School

George L. Wilcox, Associate Professor

Computers have made significant inroads into both medical practice and biomedical research. It is therefore a high priority of the Health Sciences to expose medical students, other health professionals, and graduate students in the basic medical sciences to microcomputers. The Woksape projects administered through the Medical School are encouraging development of microcomputer applications in diverse fields of research and teaching in biomedical areas ranging from the levels of genes and macromolecules to those of cells and organ systems, and even to entire anatomic structures.

One Woksape-funded Medical School project will extend student microcomputer use by coupling relatively inexpensive PC workstations to videodisk players. The players will display movies generated from sophisticated three-dimensional simulations and animations of dynamic anatomical models. The PC will guide the student through lessons, provide detailed study in areas requiring attention, and allow the student to skip areas already learned. This application will allow the investigators to bring students into indirect contact with technology that cannot be economically provided to them on an individual basis: i.e., 3-D graphic workstations with animation software. Two other projects will allow students to manipulate simulations of biomechanical or neurophysiological interactions. Such hands-on interactions with simulations can significantly enhance a student's appreciation of the important parameters in the function of the body. Another project is developing new methods of steering students through a complex diagnostic field involving heart sounds. In this, PC workstations will provide an inexpensive way to present the sounds repeatedly, so that students can learn the sounds associated with various pathologies better than is now possible.

Woksape projects are encouraging interdisciplinary developments of educational technology in the biomedical sciences. Future developments in this field may include incorporation of sophisticated graphics applied to biomolecular, biomechanical, and organ system simulations. Visual interaction between the student and the "teacher" will allow development of entirely new methods of instruction in the future.

Project Number: MED01

Computer-Aided Instruction in Anatomy Using Videodisc Display Technology and Three-Dimensional Graphics

Jean E. Magney
Department of Anatomy
Charles K. Knox
Department of Physiology

Purpose

Design and development of an interactive videodisc program for first year medical students and undergraduates in the allied health sciences is in progress. Based on the anatomy of the kidney, the program integrates form with function and uses a variety of high-technology devices in its presentation.

Progress

Techniques available to basic scientists, including all modalities from scalpel to electron beam, are used to describe the kidney. We have videotaped the dissected cadaver to establish gross relationships between the kidney, other internal organs, and the body wall. Microphotographs and illustrations are part of the visual material on disc.

A sophisticated 3D computer graphics package (Model, Preview and Image from Wavefront Technologies), provided in part by Project Woksape, is used to enhance biological materials digitized on equipment already available to us in the Biomedical Image Processing Laboratory.

As an example, a student may see an illustration of a renal corpuscle and learn its component parts. He or she is then asked to identify these parts on a transmission electron micrograph of the renal corpuscle. Next, the inside of the corpuscle is viewed at low magnification by the light microscope and at higher magnification, by a scanning electron microscope that shows details of the visceral epithelium. A motion-picture segment then describes the filtration barrier of which the epithelium is a part. After a tutorial on the filtration barrier as a unit, computer animation describes the process of glomerular filtration.

Within this short segment, the student might be questioned on the development of the renal corpuscle in the embryo, or on the location of renal corpuscles in the kidney. Students study blood flow to the renal corpuscle and are asked to describe the effects of changes in blood flow on glomerular filtration. As feedback, they see another computer animation based on different parameters. If a student is interested in the clinical manifestations of diseases affecting the renal corpuscle, he or she may choose to view short tutorials and will receive references to further reading on the subject.

We designed our project for delivery on the IBM Infowindow system. We first completed a proof disc that resulted in some changes to the visual material. We have now completed the master videodisc and have had ten replicas made.

The final phase of our project is underway, with programming being done using the IBM Authoring System, LS1. We are incorporating PC graphics in the program, using Microsoft Paintbrush, because the images are easily transported to LS1.

Future Plans

The Fall 1989 Medical School class will be used to evaluate our program.

Equipment

2 PC/ATs with Enhanced Graphics displays
2 InfoWindow displays
2 Proprinters

Project Number: MED02

Learning Cardiac Auscultation

James H. Moller
Department of Pediatrics

Purpose

The intent of our project is to provide an efficient means for medical students and residents to learn a broad range of cardiac abnormalities through an understanding of both cardiac auscultation and physiology. To accomplish this, actual heart sounds and murmurs recorded with International Acoustic Incorporated's (IAI) digital stethoscope will be incorporated into programs that teach the seven major heart sounds and individual cardiac diseases.

For developmental purposes, the project is divided into 4 sections:

1) writing text,
2) creating questions and a set of unknown sounds for testing,
3) developing software, including extensive graphics, and
4) incorporating heart sounds directly into our program (Currently the sounds are accessed through IAI's own program).

The information presented in "Learning Cardiac Auscultation" is organized in three teaching modules: 1) heart sounds, both physiologic and abnormal; 2) specific cardiac diseases; and 3) other, innocent, heart sounds.

Progress

Using IAI's digital stethoscope to record heart sounds, we have built an auscultatory library with representative sounds from these three groups. IAI's technology for digitizing and storing sounds allows for an excellent reproduction of sounds presented by cardiac patients at the University's hospital and clinic. Under the direction of Dr. James Moller, a fourth-year medical student has researched and written the program's text, and has also directed the integration of textual and graphic information.

Since many people retain information best when it is presented in more than one form, we have developed a program that is rich in its use of graphics and color as well as in text and sound. We expanded both the Pascal Instructional Language (PIL) and graphics package (technical note #3) developed by the University of Minnesota's Microcomputer Systems Group in order to enhance the user's learning experience.

Throughout the program, color is used to highlight important ideas and to clarify diagrams and pictures. Simplified pictures of cardiac abnormalities (complete with animated blood flow) reinforce the reasons and location of particular murmurs. A diagram of the precordium aids in discussion of the location on the chest at which to listen for particular murmurs, their origin, and direction of radiation of sound. Other diagrams show each murmur's specific qualities: its shape, duration, and timing. We also developed graphics that present each heart sound's relative position in the cardiac cycle and its amplitude in comparison to other sounds.

With an eye toward the computer-illiterate user, we have made the program flexible and easy to use. Menu selections allow the user to change between different areas of the program. Complete instructions appear on each screen, and the user can scroll either forward or backward through each section. Each area has an introduction familiarizes the user with important concepts and new graphic images.

Future Plans

The remaining aspects of the program present challenges. One concerns incorporating heart sounds into the program. Currently, heart sounds are recorded, stored and reproduced using IAI's digital stethoscope and software. The quality of these sounds is excellent; the amount of time needed to transfer the digitized information from the computer to the stethoscope is, however, unacceptable. To achieve both quality sound and speed of transfer, we propose using IAI's stethoscope to record and store sounds, and to develop software that will reroute the digitized information through our own analog-to-digital / digital-to-analog board for playback. The University's Engineering Services group of Academic Computing Services and Systems is currently investigating the extra hardware that we will need to accomplish this. IAI has loaned us an edited version of the source code they use for playback. We anticipate a significantly shorter time needed to load heart sounds once we discover how IAI stores each record.

Second, a wider library of heart sounds and murmurs needs to be gathered. Currently, we are working with Thomas Johnson, Assistant Professor of Psychology, University of Minnesota, Morris, to record a variety of sounds from patients on reel-to-reel tape. These are being stored for subsequent use.

Thirdly, through research previously performed with Professor Johnson, we have identified methods of developing materials to test auscultatory skills. This fall, we will identify specific areas in which to test auscultatory skills, outline the sequence for testing, and identify the type and characteristics of heart sounds and murmurs required to develop the materials. It will then be necessary to identify these auscultatory phenomena in our library or to record additional material and then organize the sounds into our testing material.

The principal investigator has recently been awarded a grant to develop an interactive videodisc on congenital heart disease. The videodisc will present a variety of visual images, such as from x-ray or electrocardiography. The visual materials and recorded heart sounds developed during the Woksape project could be valuable additions to this program, and we will investigate their incorporation as that project progresses.

The program, Learning Cardiac Auscultation, is scientifically accurate, uses sound educational techniques, and exploits the capabilities of the computer. Once sound can be incorporated into the program, the result will be outstanding and unique.

Equipment

1 PC/AT with Enhanced Graphics display
1 Proprinter

Project Number: MED03

Orthopaedic Biomechanics Teaching Aids

J.L., Lewis, R.C. Thompson, and R.E. Hunter
Department of Orthopaedic Surgery

Purpose

It is proposed to enhance training of orthopaedic-surgery residents and engineering-biomechanics graduate students by forming teams of residents and engineering graduate students (one of each) to create biomechanics teaching software modules. The residents will define clinical problems, assist in program development, and interpret the results; the engineer will write the software and solve mechanical problems. Computer graphics will illustrate analytical concepts. Experience will be the training process, but a software module will result as well. In addition to teaching biomechanics, the process will formally introduce the orthopaedic resident to computers.

We also propose to develop computer-graphics programs to illustrate knee-joint laxity or subtle motion changes that occur after injury or repair. Both comparison of two static joint configurations and simple animations will be developed. Input data for the motion will come from experimental research data we are currently generating. The resulting programs will serve as aids in teaching medical, paramedical, and research personnel the changes in joint laxity or motion that occur after injury and surgical repair, and between different types of repair.

Progress

A lesson module for teaching statics to orthopaedic residents was written, using Storyboard to generate graphics and text. Residents are testing the program; we will make alterations as warranted.

Equipment

2 PS/2 Model 50s with VGA displays
1 PC/XT with Enhanced Graphics display
3 Proprinters

Project Number: MED04

Computational Molecular Biology in the Laboratory: Software for Recombinant DNA and Genetic Engineering Technology

Ernest F. Retzel
Department of Microbiology
Medical School

This proposal centers around the development of a suite of workstation programs primarily to serve the students of Microbiology 5125 (graduate students, advanced undergraduates, medical residents and technical staff) and, by extension, the laboratories and departments of which the students are members.

The basis of this proposal is that genes and their products can be defined at the most basic level as long strings of four letters [the individual bases in DNA] or of twenty letters [the amino acids in proteins], representing the chemical units from which the genes and proteins are assembled. For many purposes of biotechnology, these strings can be manipulated by computers using programs that incorporate the physical, chemical, and biological properties of components of the strings as they are represented in nature. In addition, many of these properties can be graphically depicted after analysis, making the comprehension and comparison of complex phenomena relatively easy.

This project is directed toward developing a software package with the following attributes: 1] programs capable of performing various analytical tasks, particularly by reducing a large problem to several smaller problems; 2] aids in protein sequence determination; 3] aids in the design of synthetic protein molecules; 4] aids in the design of synthetic DNA molecules; 5] emphasis on graphical rather than textual output format; 6] access to LANmark ethernet in order to access data bases stored at other facilities; 7] manipulation of data in a format compatible with other programs and facilities maintained as university resources; and 8] portability to other IBM personal computers to be explanted to student laboratories upon completion of the course.

Initial work has been begun on this project, even though the machine will not be delivered until later this year. We have begun work on one of the ancillary programs, namely, that for the detection of potential antigenic sites in proteins. This program does not depend so much on the data format as some of the others we are developing and, consequently, was one of the easier ones on which to begin while we continue to develop the overall structure of the programs and what will be included. This particular program was chosen because the output will be particularly useful in the early stage of the class, and can be used directly to predict regions in the proteins of interest for further study. Initial raw data will be textual in nature; a fourier transform of this data will provide a graphical output.

Also proceeding is the more difficult task of assembling the algorithms for implementation in a single program format. We want to make the program sufficiently comprehensive for both class and research use without trying to do everything and accomplishing nothing.

Equipment

1 PS/2 Model 80 with 8514 display
1 Proprinter
1 Color plotter
1 Streaming tape drive

Project Number: MED05

Software Nervous System for Students

Donald C. Quick
Department of Orthodontics

Purpose

The program developed for this project simulates behavior in a small nervous system, and is useful for experimentation and research, and for instruction in neuroscience courses. The software was designed to run on a minimally-configured microcomputer and to be very easy to use.

Progress

The project has been completed. The simulation program, titled ''NERVOUS,'' has been published commercially, along with a user's manual. The program and manual are available in the Biomedical and Dental Learning Resources Centers.

A related simulation program, ''SQUID,'' has also been developed using resources provided by Project Woksape. This program simulates the electrical activity in a squid giant axon. Like NERVOUS, it can serve as a subject for experimentation. It has also been published with a user's manual and is available in the Resource Centers.

Future Plans

A new grant from the Academic Health Center will enable us to continue development of simulation software for the neurosciences. The next program will be a simulation of cable properties (relations between geometric and electrical parameters) in nerve fibers. This program and any subsequent ones in the series will be bundled with NERVOUS and SQUID to be distributed as tools for neuroscience education.

Equipment

1 PS/2 Model 50 with VGA display
1 Proprinter

School of Nursing

Impact of Project Woksape on the School of Nursing

Cynthia R. Gross, Assistant Professor

The School of Nursing was fortunate to have two Woksape grants. These grants have supported the development of three clinical-nursing simulations to enhance nursing knowledge and decision-making, and the creation of a CAI-based nursing-administration course on financial management. The first of these software packages has been used in nursing courses, and the others will be introduced in the coming academic year. Project Woksape provided faculty with the impetus to explore the instructional capacity of microcomputers, and the opportunity to adapt novel and diverse instructional approaches.

The environment for the entire nursing faculty has been greatly enriched. Project Woksape has generated a core of computer-literate nursing faculty and increased the availability of high-quality hardware and software. As our Woksape-funded faculty endeavored to accomplish their particular instructional-computing goals, they enhanced their personal knowledge of microcomputing and such related technology as videodisc. They have become widely recognized within the School for their technical expertise, and have been used as the School's advisors in further hardware and software acquisitions. The peer-level transfer of technical knowledge has been assisted by the creation of a Nursing Faculty Development Computer Laboratory funded by a grant from University of Minnesota Instructional Computing funds. The objective of this lab is to provide opportunities for all interested faculty to explore computing, and much of the hardware and software selected for this facility was chosen with the advice of our Woksape grantees. Pretesting of Woksape-developed instructional computing packages was facilitated by this lab.

The School of Nursing focused first on faculty computing. The expectation was that faculty who relied on computers for their own needs would be likely to generate opportunities for students to use computers as well. This has been an effective strategy. The number of faculty engaged in computing has dramatically increased over the last five years, and more computer hands-on learning opportunities are being proposed for nursing students each quarter. Woksape has been instrumental in ''seeding'' our School with leaders in this effort.

Project Number: NSG01

Clinical Simulations of Complex, Acute Care Nursing Situations Utilizing CAI

Karen L. Alaniz, Laura J. Duckett, and Dorothy M. Fairbanks
School of Nursing

Purpose

The purposes of the project are: 1) to create a link between the classroom and clinical components of a complex, acute-care, senior nursing course in the form of three computerized clinical simulations; 2) to appraise the students' knowledge acquisition and decision-making skills as determined by performance in these simulated situations; 3) to evaluate the influence of learner characteristics and the use of the CAI on students' synthesis of course material and attitudes about using CAI; and 4) to develop and pilot an instrument to evaluate the impact of this computerized instructional strategy on the enhancement of selected components of students' actual clinical decision-making.

The computer simulations are designed to facilitate the development of critical thinking skills in undergraduate nursing students. The format being used incorporates clinical judgment-making within the context of the nursing process. The simulations also will provide learners with opportunities for useful self evaluation of both basic knowledge and processing skills that are essential for clinical practice.

Progress

Simulation I: Emergency Room - Asthma
Karen Alaniz

Description. This simulation focuses on a young adolescent who is brought to the emergency room while experiencing an acute asthma episode. It is composed of three sections: a pretest, a clinical simulation, and nursing grand rounds. The pretest is a random ordering of 10 multiple choice questions. The student must answer 8 correctly to continue. The simulation is a series of questions that take the student from the patient's admission to the emergency room to the point of discharge. It is based on an actual case and includes a menu through which a glossary, lab values and medical records can be retrieved. During the nursing grand rounds, the student is asked to complete nursing diagnoses and develop a care plan. Answers are compared to those an expert might give; this section may be printed.

Current Status. The entire simulation has been programmed and extensively reviewed by all three project faculty. Alaniz and Fairbanks are completing the process of editing and modifying the simulation.

Time Line for Completion:
By May 20, return edited material to programmer for final programming revisions.
By June 20, programmer completes revisions.
During Summer Session I, use simulation with senior students taking N5615, Complex I.
1989 - 1990 Academic Year, continue using simulation with students.

Simulation II: Emergency Room - Trauma
Dorothy Fairbanks

Description. This simulation focuses on assessment, priority setting and intervention with a young man involved in a motorcycle accident. This situation involves a series of respiratory, cardiovascular and abdominal emergencies ensuing from multiple trauma. The student is expected to apply principles of advanced-trauma life support within a limited time frame.

Current Status. Most of the content has been written. The same instructional design that was used for the ER - Asthma simulation will be used for this module. Therefore, it seems wise to have the same programmer do the programming for this simulation. With the same instructional design and the same programmer, the programming for this module is expected to proceed much more rapidly.

Time Line for Completion:
By June 20, give simulation content to programmer for programming.
By July 20, initial programming completed.
By August 20, faculty editing and modifying completed.
By September 20, programmer completes revisions.
1989 - 1990 Academic Year, use simulation with students.

Simulation III: Very Low Birth Weight Neonate
Laura Duckett

Description. Critical-nursing decision making, which is central to the care of very-low-birth-weight neonates with respiratory distress syndrome, is the focus of this simulation. The ''composite'' infant in the simulation represents similar infants who are typically in the Neonatal Intensive Care Unit at the University of Minnesota. This simulation will include a clinical simulation and nursing grand rounds similar in design to those sections of Simulation I. There will be no pretest, but a portion of the simulation will require students to solve a variety of problems in administering medication. These will include: 1) determining whether or not various drug orders are appropriate for the age, weight and condition of the infant; 2) calculating amount of medication to be given; and 3) determining under what conditions ordered medications should and should not be given. It is intended that the computer program will be written so that doses to be given are varied randomly within set parameters. Students will get feedback both about the correctness with which they set up problems for solution and the correctness of their answers.

Current Status. The macro design of the simulation is complete, and the micro design is being finalized. The content is partially written.

Time Line for Completion:
By June 20, finalize micro design, complete the content in preparation for programming, and hire a programmer.
By July 30, initial programming completed and videotaping completed. (Students will view a short segment of videotape of a very low birth weight infant prior to doing the simulation.)
By August 15, faculty editing and modifying completed.
By Sept. 15, programmer completes revisions.

Other Activities
An analysis of critical thinking skills at various levels of clinical competency has been prepared, together with a clinical evaluation tool. The tool will be used in an attempt to evaluate the effectiveness of this type of computer-assisted instruction in relationship to students' actual clinical performance.

Equipment

1 PC/AT with Enhanced Graphics display
1 Monochrome display
1 Proprinter

Project Number: NSG02

Computer Assisted Financial Management Instruction

Sandra R. Edwardson and Judy Beniak
School of Nursing

Purpose

The continuing move to prospective payment systems for health-care services has increased pressure on providers to improve productivity. Although most health-care facilities are now using commercially-available, computerized cost-analysis systems, most nursing administrators lack the skills to make full use of them. Experience has shown students to be so preoccupied with learning the technology that they lose sight of the financial concepts they need to function in today's health-care system.

The proposed project is the pilot phase of a long-term project with the goal of converting core concepts from the financial-management course into autotutorial, computer-assisted instruction. Content for the long-term project will include hospital cost behavior; methods for cost finding, financial analysis, and estimating the feasibility of new programs and equipment; and basic budget development and monitoring principles. The instructional packages will be used in ongoing University courses, in continuing-education programs held on campus, and as self-study modules for use by practicing managers in their own settings.

Progress

Five computer-assisted learning modules have been developed:

(1) Introduction to computer spreadsheets and Quattro tutorial;
(2) Break-even analysis;
(3) Cost/volume relationships;
(4) Calculating staffing requirements; and
(5) Budgeting exercise.

The modules are being programmed within the Quattro macro facility to reduce the hardware and software requirements and thereby increase portability. Programming of two of the modules is near completion, and the remaining programming is scheduled to be completed by September, 1989.

Future Plans

When we have completed the pilot project, the budget-development and monitoring units of N-8702, Nursing Administration II, will have been converted to computer-assisted instruction. Goals are to:

(1) develop a computer-assisted instruction (CAI) module to teach students to analyze financial data and to project and monitor financial trends,
(2) reduce learning obstacles related to lack of experience with computer technology, and
(3) increase the knowledge and experience of the project directors with computer-assisted instruction, in anticipation of a larger grant application to accomplish the long-term goals.

Equipment

1 PS/2 Model 50 with VGA display
1 Proprinter

College of Pharmacy

Impact of Project Woksape on the College of Pharmacy

Ronald S. Hadsall, Associate Professor

Developments in microcomputer technology have had an impact on virtually every aspect of the practice of pharmacy. The recognition of this reality has encouraged the University of Minnesota College of Pharmacy to evaluate ways of integrating this technology into its educational mission. Proper integration will provide our students with opportunities to develop microcomputer skills. In an attempt to meet this goal, the College has developed a demonstration pharmacy computer system for use in the practicum laboratory. Additionally, the College, with funding from the Century Mortar Club, has constructed a microcomputer lab for use by students of the College of Pharmacy. Project Woksape has provided the incentive for faculty to investigate areas of instruction in the College that could be enhanced or facilitated by computerization.

The College of Pharmacy has been fortunate in that two of the seven proposals submitted have been approved: Drug Therapy Training and Patient Simulation CAI Models, by Robert J. Cipolle; and Chemical Aspects of Drug Disposition: An Interactive Learning Module, by Rory Remmel. The proposal that was funded, Drug Therapy Training and Patient Simulation, is progressing extremely well and has had the unanticipated result of promoting a joint working relationship outside the university community. A full description of the project follows.

Faculty of the College of Pharmacy will continue to look for innovative ways to introduce CAI methods into its graduate and undergraduate curricula. Project Woksape and other university-affiliated programs have contributed significantly in this endeavor.

Project Number: PHR01

Drug Therapy Training and Patient Simulation CAI Modules

Robert Cipolle
Department of Pharmacy Practice

Purpose

Our goal is to develop teaching modules and patient case simulations in major areas of pharmacotherapy. These will demonstrate to health-science students the framework, data and interpretation of drug-related information necessary to optimize drug therapy in individual patient situations.

Progress

The clinical case situation (deep venous thrombosis requiring antithrombin pharmacotherapy) and all associated data have been collected for the initial case. We have also compiled standardized normal lab values which will be applicable for all subsequent case examples. After considerable review of existing programs, major progress has been made in identifying software support for this project, and a written agreement has been negotiated with DataMed Clinical Support Systems of Minneapolis, Minnesota to use portions of their proprietary pharmacokinetic/pharmacodynamic software for this educational project. This includes their screen displays, graphics, printed case-consultant reports, and programming assistance.

Additionally, we have reviewed several software packages to assist in the authoring process of these case simulations. Recently, we have decided to use Autotrainer (Software Recording Technology) to create and incorporate screens for users. The text and flow for over 100 screens has been developed for the initial case simulation. These include three levels of help screens: 1) how to run the case simulation program, 2) definition of clinical terminology and abbreviations designed to help the novice user, and 3) interpretation of the case information as it applies to the specific case.

Other changes have been incorporated into the design of this project. It is not being designed as a test, and the user will not receive a grade. The users will receive feedback as to the completeness with which they have examined the case, and a parallel example of how an expert would have evaluated the therapeutic problem. Additionally, we are incorporating probabilities of success given the patient situation, which will sometimes yield negative patient outcomes, even if the user makes all of the preferred choices. This aspect of the software design is used to more closely simulate real-life situations and to introduce the user to the concept of treatment failure.

Future Plans

Yet to be completed are: 1) Additional screens for the therapeutic drug monitoring sections. 2) Assignment of cost data to specific user-selected screens. This will allow us to give the user feedback as to the effectiveness, efficiency, and expense of his/her drug-therapy decisions. 3) The draft program will be extensively field tested by student users, as well as by experienced clinicians. 4) We also plan to develop additional, more complex case simulations that will require minimal development following completion of this initial case.

Application of these case simulations to College of Pharmacy coursework will be greatly facilitated by our newly developed Century Mortar Club Computer Laboratory. Students will be able to work with the Woksape cases at their own pace in this laboratory.

Equipment

2 PC/ATs with Enhanced Graphics displays
1 PC/XT with Enhanced Graphics display
3 Proprinters

School of Management

Impact of Project Woksape on the Carlson School of Management

Mary K. Weber, Assistant to the Dean

As part of the mission of the Carlson School of Management (CSOM), we are committed to providing our students with the skills, theories, and hands-on experience necessary to meet the expectations and demands of the business community.

The CSOM received a Woksape grant to develop an innovative method for teaching students the principals of economic markets. The new method of instruction that has been developed through the grant enables students to simulate the action of economic markets. This is accomplished by building the software required to establish computerized markets to demonstrate the principals of economic theory.

The project team developed the software tools necessary for conducting experimental economics on a personal-computer network. The software was developed and tested on a four-station IBM Token-Ring network provided by Project Woksape. After development was completed, the software was taken to the CSOM's 16-station student computer laboratory where three test markets have been run. These test markets have demonstrated the advantages of presenting economic theory using computerized markets. Traders quickly learn how market forces work. The computerized economic markets developed by this project are real-time, interactive simulations of market forces.

Use of a computer network for information storage and for simulating these market dynamics has, in addition, freed students from performing tedious accounting and information record-keeping functions, thus assisting them in gaining an understanding of market forces.

The CSOM is creating an environment that attracts top-quality students and faculty. Programs such as Woksape are a key component in fostering this environment. It has enabled the faculty to develop an innovative curriculum that prepares our students for what faces them when they operate in a wide range of markets.

Project Number: SOM01

Computerized Economic Markets as a Teaching Method

Gordon Duke
Department of Accounting

Purpose

This is a proposal to develop an innovative new method for teaching principles of economics: the use of computerized markets. Students will actively trade assets over a computerized network. All information about the market will be displayed on the computer screen. All input from the students will be from the keyboard. The power of the computer network, coupled with student participation in an active market, brings a realism to the teaching of economics that can augment and supplement traditional methods of instruction.

Graduate students in business will learn the fundamentals of economic markets by participating in trading. All traders will operate from personal-computer workstations networked through the IBM Token-Ring Network. They will make decisions to buy, sell, or hold assets based on information made available to them at the computer screen and controlled by the instructor. Various forms of markets, such as monopolies, asymmetric information and many forms of auctions, can be demonstrated. Having participated in markets, the students can better understand economic theory.

Progress

We have completed the first market and have prepared some preliminary materials for running that market. That market will be submitted to WiscWare shortly.

We have previously developed the methodology and software for running computerized markets (under a separate Woksape grant). We have tested the methodology on three groups of graduate students and faculty. The markets run reliably, and participants are quick to grasp the functions of market forces. This project takes that methodology and develops the specific markets required to teach principles of economics to graduate business students.

Future Plans

We are presently completing the teaching notes for the first market and will begin work on the second and third markets soon. These notes will be tested on a class of introductory economics students during Fall Quarter, 1987. A second market, the market for audit services, was tested on a group of faculty and graduate students on Friday, 28 August, 1987. Some technical problems were discovered. We plan to modify the control program for the markets to allow the operator to correct these problems if they recur.

Equipment

1 PS/2 Model 60 with VGA display
1 PS/2 Model 50 with VGA display
1 PC/AT with Enhanced Graphics display
3 PC/XTs with Enhanced Graphics displays
2 Enhanced Graphics displays for existing PCs
1 Proprinter
PC Network

Project Number: SOM02

The Knowledgeable Interview Subject System (KISS)

J. David Naumann and
Cynthia M. Beath
Department of Management Sciences

Associates: Macedonio Alanis,
Richard Ye, Yu-Kuang Lim, John Libra

Purpose

The most critical step in the development of an information-processing system is determining user requirements. Systems analysts in business, engineers in software development, and knowledge engineers in expert-systems development rely heavily on the personal interview for information gathering. Typically, interviewers discover conflicting, incomplete, and inconsistent facts, opinions, needs, and desires, and must combine them into a complete and consistent requirements document or prototype system.

The initial objectives of the KISS project were to develop a hardware and software system that would respond to questions about a specific knowledge domain in about the same way as would a human interview subject. KISS is intended to support both teaching and research in Systems Analysis by providing a laboratory setting for student assignments and controlled experiments. A student user of KISS has a specific analysis task, and conducts an interview by typing questions on the keyboard. KISS responds to the questions it "understands" in English (graphic or printed materials may also be produced in response to certain questions). KISS is organized around a knowledge base that contains facts about the organizational units, people, processes, and data that make up a particular requirements determination knowledge domain or case. The KISS knowledge base may be modified or redefined by the researcher or teacher to encompass a different knowledge domain.

Progress

The KISS knowledge base has been organized as a hierarchy of *frames*, each of which refers to and describes one or more "real-world" entities. Each frame is either a *class* frame or an *instance* frame, meaning it either describes properties that apply to many instances in the corresponding "real world," or to one specific instance. Each frame is made up a number of *slots* and, in turn, each slot may (a) contain a value that applies to a class or an instance, (b) derive a value, when queried, from a related frame, or (c) contain a program that computes a value or set of values when triggered by a question.

There are three broad classes of frames in KISS: actors, processes, and data. These broad classes include several sub-classes. For example, an actor frame may be an organizational unit, a position, or a person. Frames are also interconnected by *relationships* that are analogous to relationships in the world. For example, a manager [actor] is responsible for [relationship] an operation [process]. The contents of the knowledge base are constructed by first describing organizational units, positions, people, processes, data files, structures, reports, etc., both one at a time, and as classes. Secondly, relationships among classes are defined, and finally relationships among selected instances are specified. The result is a complex knowledge structure that contains information such as that in the following example:

The *manager* [position class frame] of *Finance* [organizational-unit instance] is *John* [person-instance frame]. John is *responsible for* [relationship] *produce financial statements* [process-instance frame], *create credit instrument* [process instance], ...

The KISS user interface is primarily English-language statements. The user types a question as a complete, grammatical sentence, and the interface responds with an English sentence that has been generated from the facts contained in the knowledge base. (The knowledge base also contains a few "canned" responses that are output directly. The most common of these are simple text descriptions of instance frames, for example, a text description of a process.) The user interface has been constructed using a "Lexical Functional Grammar" *parser* and *generator* tool.[1] Using the parser, a simple grammar encompassing a broad range of English questions was constructed. The grammar includes a dictionary derived from the contents of the knowledge base, and is therefore specific to the case being used.

The parser converts a question into two internal representations: a grammatical parse tree, and a knowledge-base query. The knowledge-base query is processed by the knowledge base, which returns the results of its search. Thus, for example, the question "What does John do?" is transformed into a knowledge-base query that searches for the list of things pointed to by the slot "does" of the frame "John."

The results of the knowledge-base search plus the parse-tree representation of the original question are then passed to the sentence generator. The generator converts the combination of the original question and the answer into one or more grammatical English statements. The generator has its own grammar and dictionary, which are closely related to the parser's grammar.

KISS is not completely operational at this report date (May 31, 1989). The project team is currently revising the generator grammar to produce a broader range of grammatical responses. The input parser and grammar combination, and the knowledge base work together reliably for the set of questions expected. Our experience to date suggests that student questions relevant to the knowledge domain will be properly interpreted and answered. Completion of the generator grammar will close the loop, and will permit planned pilot use to proceed during the summer.

Overall, the KISS project has been delayed by a number of unforeseen events and problems: the hardware configuration was revised, and therefore delayed, several times to take advantage of the PS/2 Model 80. The underlying software, Gold Hill Common Lisp, was not available in the correct version, and was not delivered when promised. The search for public-domain, natural-language parser software took much longer than anticipated. Finding competent programmers was very difficult and time-consuming. As a result, several features that had been planned to make KISS more useful or more convenient to use have not been implemented, and system testing remains to be done.

Future Plans

At this time, we are looking forward to both pilot testing this summer and, if testing is successful, full use in the fall.

Equipment

1 PS/2 Model 80 with VGA display
1 Proprinter

1 The Generalized LR Parser/Compiler was provided by the Center for Machine Translation, Carnegie-Mellon Univ.

University Counseling Services

Impact of Project Woksape on University Counseling Services

Elizabeth Wales, Director

In the first year of the Woksape program, the University Counseling Service (UCS) received a Woksape grant to further counselor-training activities. The proposed counselor training the Woksape grant supports is carried out in conjunction with faculty in the Department of Psychology, the College of Education, and units of the Medical School. The Woksape grant enables UCS to continue to make a contribution to the counseling profession in terms of new and better ways to train counselors.

The grant has had several effects on the UCS. One is the impact on specific aspects of counselor training. In part, changes come from prior effort under the Woksape grant, such as the program to teach new counselors to make a differential diagnosis of test anxiety. Besides diagnosis, the program also suggests treatment options based on empirical outcomes. Trainees' use of the program helps them to expand or deepen their learning on their own initiative. At this time, the program is being revised. The current objective is to broaden the program so that, in addition to decisions about test anxiety, it can model diagnoses for vocational choice and academic motivation problems.

The second training impact is on the use of the Minnesota Multiphasic Personality Inventory (MMPI). A program under development will help trainees learn to interpret this very widely used assessment instrument. Again, the student can use the program individually to expand on instructional time. Thus, the Woksape grant has allowed UCS to offer more flexible, increased instruction in important topics with less supervisor time involved.

The third impact has been on UCS research. The Woksape grant stimulated UCS to install a computer-assisted program for short-term, focused counseling. This activity, called the Therapeutic Learning Program (TLP) has not previously been used extensively with a university student population. UCS staff are engaged in a controlled comparison of computer-assisted group and individual counseling. The data may increase our understanding of what kind of treatment is most effective for what kind of client, and of the role of computers in personal counseling.

Project Number: STUD01

Computer Applications in Counselor Education

David M. Wark
University Counseling Service

Purpose

The initial purpose of the Woksape grant was to explore computer applications for training advanced graduate students to become professional counselors. Part of their learning was to master seven stages in the counseling process:

Stage 1: Use basic interviewing skills
Stage 2: Identify and set counseling goals
Stage 3: Build a professional relation and trust
Stage 4: Assess the client's psychological state
Stage 5: Develop therapeutic interventions
Stage 6: Integrate and generalize therapeutic growth
Stage 7: Terminate counseling

The Woksape grant was requested in order to develop a computer-implemented experience at each step in the process.

The planned applications covered a broad range of computer technology. The proposal included computer-assisted instruction, simulation of clients, computer-driven biofeedback, graphic displays of psychometric data, and modeling of diagnosis by an expert system. The original proposal assumed a five-year time frame. In retrospect, even five years was not enough to plan, program, and establish all of the applications. In actuality, the Woksape grant stimulated more ideas than were actually accomplished in the three years of support.

Progress

By the third year of the grant, computer applications have been developed for the following stages:

Stage 2: Identify and Set Counseling Goals

Insight 1.1, an expert-system shell, was used to develop a three-part model for diagnosis and treatment of test anxiety, which is estimated to affect 20% of the student population at some time. The program takes data from student admission records (high-school graduation rank and ACT or PSAT admission tests), client interviews, and personal history. The output is a set of suggestions for the counselor trainee to use in setting client goals to reduce test anxiety.

The program was available for use by graduate students in the Counseling Practicum, Psy 8514-5-6. One IBM PC/AT was designated for use by the trainees, who enter data and obtain printouts about their clients. The trainees' documentation kits include copies of psychological measures for further diagnosis. Treatment manuals are also available. Practice materials for test-anxious clients were prepared and placed in the Learning and Academic Skills Center for easy access.

The program was targeted for further refinement. Decision rules were written to classify students as possible late bloomers (low class rank, high ability), creative focusers (midrange class rank, high ability) or super leaders (high class rank, high ability). The using counselor would receive suggestions from the program about possible goals for the client. We discovered after the deadline for budget submission that the AT computers would have to be upgraded to 640K in order to handle the expert-system shell needed to build the new features. In addition, it seemed unlikely there would be enough time in the support grant for a research assistant to do the required programming. The decision was to stop work on program refinement at this time, and to put effort into other aspects of the Woksape project. The first version of the program was, however, described in IBM materials. Counselors in California and Taiwan have requested information and received copies of the program and documentation. The program will also be listed through Wisc-Ware.

Stage 3: Build Professional Relations and Trust

The Woksape program provided University Counseling Services some physiological monitoring equipment. A few staff went through a familiarization program. A graduate student planned to use the equipment to study the relation between reduction of tension and the increase of treatment skills in second-year graduate students learning to be counselors. As they became more relaxed in their training sessions, they should be better able to learn new complex skills for working with clients.

CLIENT 1, a computer simulation of some basic counseling techniques, was chosen as a standard behavioral criterion measure. The sooner the trainee uncovered the basic problem presented by the simulated client, the higher the trainee's skill score. The goal for this stage's training was to use the computer-monitored equipment to help the trainee reduce tension that would interfere with learning how to respond to the client.

Unfortunately, variability in the physiological measures monitored by the computer was higher than expected. Statistical analysis indicated that the number of student trials needed to produce reliable results was larger than expected. It would have taken an unacceptable amount of time to carry out the training. Human supervisors were more efficient in helping the trainees relax and presenting the necessary clinical instruction.

Stage 4: Assess the client's psychological state.

In 1986-87, a program to teach interpretation of the MMPI was started. The objective was to develop a teaching aid to assist the counselor trainees in three ways: 1) organize research about the MMPI so it could be retrieved quickly; 2) conveniently provide alternative interpretations of a client's score; and 3) manage the mechanics of printing the trainee's interpretation.

The program has gone through two versions during the life of the grant. In the first, the counselor trainee enters a client's MMPI scores for 13 scales. The program then sorts the scale scores from high to low. Then the trainee is offered a menu of interpretations grouped by score range. Thus, the trainee's attention is focused on scores suggesting serious problems that need to be addressed first. But this version offered only elementary interpretations, based on single scores. Advanced use requires an understanding of the complex patterns of all the scales. So the next step is to create a training aid that could present any of the hundreds of combination scores that have been documented in the research literature.

The second version of the program asks trainees to enter two highest scores in the client's profile. Then it offers a research-based interpretation of the two-point code. The wording of the interpretation is specifically designed to help the trainee use language that will be appropriate when working with clients of college counseling centers. In addition, the output warns the trainee if the two-point code is associated with suicide attempts.

This version of the program is being developed for publication. A nationally-recognized expert on the MMPI is doing a review. She will evaluate it as a possible adjunct to her book on interpretations for college students. Since the program is written in the PILOT language, it can be modified or expanded to take advantage of research on the new version of the test.

Summary

The Woksape grant has produced two operational programs for training counselors, the MMPI interpretation aid, and the Test Anxiety diagnostic and treatment program. Both are evolved to the point where they can be used in the field. Moreover, each is general enough to be revised and expanded by other instructors and investigators. Research on other aspects of counselor training may be carried on after the grant is ended. In addition, the existence of the Woksape equipment stimulated University Counseling Services to install and evaluate a computer-assisted program for short-term, focused group therapy. Current results indicate the Therapeutic Learning Program helps students solve certain problems as effectively as does conventional therapy, but takes less counselor time.

Equipment

3 PC/ATs with color displays
3 Proprinters

College of Veterinary Medicine

Impact of Project Woksape on the College of Veterinary Medicine

Thomas F. Fletcher, Professor

Use of computers as instructional aids and computer literacy of students are priority goals of the College of Veterinary Medicine (CVM). Computers, originally introduced into veterinary practices for business management purposes, have become important as educational, diagnostic, and health-management tools. The computer promises a solution to the dilemma of coping with an increasingly rapid expansion of medical knowledge and an accelerating demand for more sophisticated service.

Veterinary service has two modes. One concerns the diagnosis and treatment of disease in the individual animal; the other deals with population units (herds, flocks, etc.), particularly in the contexts of agricultural economics and wildlife management. Computers are essential for effective population health management, and they are becoming important aids in delivering health care to the individual patient.

Two of the four Woksape development projects in the College relate to the individual patient. One project is developing diagnosis-assistance units by making use of a Problem-Knowledge Coupler (shell program) to establish data bases of parameter values per disease per species. Students will make use of these units to ensure they have not overlooked anything in the process of arriving at proper diagnoses. Another project deals with lameness diagnoses in horses. By making kinematic measurements and using the computer to construct vector diagrams that display gait differences in a dramatic way, the time it takes to develop competence in lameness diagnosis can be significantly reduced.

The remaining two Woksape projects pertain to population medicine. One is geared to instructing students in principles of epidemiology by computer simulation of disease-scenario problems within an instructional laboratory setting. The other project is designed to instruct students in data collection and processing for herd health management or production medicine. The goal of production medicine is to deal with factors that lead to sub-optimal animal health that impairs agricultural productivity and, thus, farm profitability. Computers are essential because of the mass of data involved in this mode of veterinary service.

Project Number: VM01

The Development of Computer-Based Veterinary Medical Teaching Aids to Promote Effective Clinical Problem-Solving

Thomas E. Stein

Purpose

The purpose of this project is to use a commercially available software package (Problem Knowledge Coupler) to develop knowledge-couplers for various diagnostically challenging clinical problems in veterinary medicine. The process consists of identifying a target problem, constructing a knowledge network using published literature and experts' opinions, creating a list of clinical facts, and linking the knowledge network with the clinical facts.

Progress

Since the project began, fourth-year veterinary students and participating faculty have developed the following set of knowledge couplers:

(1) A management-options coupler for equine lameness. Usually, couplers address a clinical problem to aid the diagnosis. In this case, we assumed the diagnosis had been made. In the field of equine medicine and surgery, the management options -- medical or surgical treatment -- are quite extensive and complicated. This knowledge coupler was created to aid the development of a treatment plan.

(2) A diagnostic coupler for bovine gastrointestinal problems.

(3) A diagnostic coupler for problems of internal parasitism.

In addition, we made contact with a group of veterinary schools, each working on knowledge couplers and using the same software. We exchanged knowledge couplers, receiving couplers on the diagnosis of swine abortion and polyuria/polydipsia in dogs.

Our assessment is that the Problem Knowledge Coupler software is below average as an educational technology development tool. The knowledge couplers themselves stimulate little creative problem-solving, and serve more as memory-joggers for diagnoses of low probability.

We have been unable to integrate these couplers into the clinical hospital rotations, due to lack of computer equipment.

Future Plans

This project has been discontinued.

Equipment

2 PC/ATs with Enhanced Graphics displays

1 Proprinters

Project Number: VM02

Computerized Reproductive Monitoring for Teaching Theriogenology in Dairy Herds

Norman B. Williamson
Department of Large Animal Clinical Sciences

This project allows senior veterinary students to use a microcomputer-based dairy herd reproductive information system currently under development, to analyze a herd's reproductive performance. Preventive herd-health visits involve collecting and analyzing the performance records of a herd, and not just diagnosing and treating individual sick cows. The major economic gains from reproductive improvements on dairy farms are due to the identification and correction of inadequacies of reproductive management and control, rather than the treatment of a few sick animals.

The system will provide performance indices for the herd in key areas of reproductive efficiency: estrous occurrence, estrous detection, conception efficiency, and reproductive culling. Students compare these indices with established targets and then enter the indices into an available reproductive model (DairyORACLE - Optimization of Reproductive Activity in Commercial Livestock Enterprises) to demonstrate the economic efficiency of current herd reproductive performance levels and changes. Since some students have just returned from farm visits and have just seen the livestock, facilities, and management, they are able to develop and test realistic alternatives for that specific farm.

The program teaches students how to use:

- the concept of herd (in addition to individual animal) performance monitoring,
- records in evaluating herd performance,
- a herd record system,
- computer modelling as a forecasting and planning tool, and
- a comparison of performance against targets as a management technique.

Equipment

1 PS/2 Model 60 with VGA display
1 Proprinter

Project Number: VM03

The Development of Computer-Based Problem Solving Exercises in Veterinary Epidemiology

Robert A. Robinson
Department of Large Animal Clinical Sciences

Purpose

The objective is to develop computer-based instructional (CBI) exercises in problem solving outbreaks of disease and identifying risk factors associated with lowered production or reproduction in animal populations. Initially, this requires determining specific disease rates (e.g., morbidity, mortality, incidence, prevalence, case-fatality, age- and sex-specific rates), as well as indices of production (e.g., mean weaning weights) or reproduction (e.g., intercalving intervals). Also, the student will be expected to develop appropriate questions that lead him/her to identify the specific risk factors in these problems, related to population, place, and time, as well as nutrition, management, and environment.

An important part of problem solving in veterinary medicine is to have an adequate knowledge base as well as technical and analytical skills. Nevertheless, unless students can develop skills in questioning clients or interrogating data bases, they will be unable to fully apply their other skills. Techniques of asking careful questions in an ordered sequence will provide them with a sound basis for work with problem knowledge couplers being developed, and with computerized herd health delivery systems (such as 'Dairy' and 'PigCHAMP') in subsequent classes in the professional curriculum. The investigators are not aware of similar CBI exercises developed specifically for veterinary epidemiology.

Investigators will develop six computerized exercises for LACS (Large Animal Clinical Sciences) 5-650 for Spring Quarters 1987 and 1988. Exercises will be designed for students to solve individually using University microcomputer laboratory facilities on the St. Paul Campus.

In the first three exercises, students will be presented with a series of data bases describing hypothetical but realistic situations involving disease outbreaks or lowered productivity. After each set of data is presented, the computer will present a series of questions designed to show by example how a client or herdsman should be interviewed to establish an orderly accumulation of information. Check questions will also be included. For each questions, five answers will be provided, and the student will choose what he or she believes to be the most correct. Explanations will be provided for both the most correct solution, and why the other options presented are less useful.

In the second set of three exercises, students will be provided with only a very brief data base concerning a disease outbreak or production problem (as they might receive, for example, following a phone call). From then on, students will be asked to develop their own set of questions based upon their experiences in the first three exercises. The student will type questions into the computer. The ability of the program to respond to questions asked in natural language is feasible as the domain is limited. Responses to the questions will contain data that may or may not be relevant to solving the problem. Students will have to continue questioning in order to receive the information available on particular aspects of the problem. It will be the student's responsibility to make judgements (including statistical tests) concerning the appropriateness of the data, and also to determine which line of questioning is required next to ultimately solve the problem.

Students will be graded on their ability to ask questions in the predetermined sequence leading to the most rapid resolution of the problem. The exercises will also be evaluated by students and clinical faculty in the College of Veterinary Medicine as to their significance and value for later curriculum subjects.

The investigators currently lack experience with authoring languages for these exercises, but have sought assistance from Project Assist and the special projects group providing general consulting on artificial intelligence. Preliminary discussions reveal that the most appropriate programming language would be LISP.

Progress

Initial work has consisted of designing the conceptual framework of the first problem-solving exercise: a hypothetical outbreak of pseudorabies in a number of pig herds.

Future Plans

As outlined in the original timeline, consultations with Project Assist and the artifical intelligence consulting group will be initiated to design the exercises. Additional financial support for programming has also been obtained for this project.

Equipment

1 PS/2 Model 60 with VGA display
1 Proprinter

Project Number: VM04

Quantitative Gait Analysis for Lameness Diagnosis

Calvin Kobluk
Department of Large Animal Clinical Sciences

The purpose of the project is to instruct veterinary students in the diagnosis of equine lameness, especially in making accurate diagnoses early in the course of disease, when treatment is most effective. The project will provide 12-20 senior veterinary students annually with the opportunity to augment traditional qualitative methods of lameness diagnosis with computer-based quantitative analyses of equine gait. Experts recognize that future progress in equine lameness diagnosis will require such quantitative gait analysis, including generating gait diagrams, which are visually dramatic and very effective teaching tools.

Students will collect videotaped data of horses locomoting on a stationary high-speed treadmill. A scanning device will generate the coordinate locations of markers placed at selected anatomical sites on each horse. For each phase of a stride, the microcomputer will generate values for various length and angle parameters based on distances between markers on the horse and the "ground." Statistical estimates of parameters per stride-phase per gait per horse will be computed, and gait diagrams (graphically illustrated vectors) will be produced visually to summarize stride characteristics per horse.

Computer software to perform these operations has already been produced for an IBM microcomputer. The programs will have to be modified to maximize didactic effect. Didactic impact will result from the juxtaposition of techniques of qualitative diagnosis with the generation of quantitative analytical parameters in a clinical setting.

The project will expose students to a new diagnostic technique which, despite its acclaimed potential, is not currently available at any veterinary school in the United States. The project will demonstrate the limitations as well as the capabilities and value of the new technology. Thus, students engaged in routine practice in the future will know firsthand when and under what conditions to refer patients to a major center to benefit from the quantitative diagnostic service. In addition, student diagnostic competence using traditional qualitative methods, which normally takes years to develop, will be accelerated by virtue of the students having precise quantitative insights regarding gait.

Equipment

1 PS/2 Model 60 with VGA display
1 Proprinter
1 Color plotter

Appendix One: Survey on the Effects of the IBM Grant for Project Woksape

1. What best describes your position at the University?

______ Assistant Professor ______ Associate Professor ______ Professor
______ Academic Professional ______ Civil Service Staff ______ Student

2. What is your college?

______ Agriculture ______ Biological Sciences ______ Cont'g. Ed. & Ext.
______ Dentistry ______ Education ______ General College
______ Graduate School ______ Home Economics ______ Law School
______ Liberal Arts ______ Libraries ______ School of Mgmt.
______ Medical School ______ Natural Resources ______ Nursing
______ Pharmacy ______ Public Health ______ Institute of Technology
______ University College ______ Veterinary Medicine ______ Other (please specify)

3. What, if any, has been the impact of the grant from Project Woksape, and your work on that project, on decisions affecting your receiving tenure or promotion? Use the middle (third) box to indicate no impact.

Very Negative — Neutral — Very Positive

4. What percentage of the total time you spend using computers is allocated to the following activities:

______ Research
______ Teaching
______ Service
______ Other (e.g., professional correspondence, electronic mail)

5. What, if any, has been the impact of the grant from Project Woksape on the quality of the following activities:

Research					
Teaching					
Service					

Very Negative — Very Positive

6. For the computer equipment granted to you through Project Woksape, what percentage of its total hours in use is taken up by the following people:
   _____ Faculty
   _____ Academic Professional Staff
   _____ Civil Service Staff
   _____ Students
   _____ Other (please specify)

7. Will you continue to develop instructional software without special funding such as that from Woksape?

   Very Unlikely — Very Likely

8. Is it likely that you will continue to use the software developed with Woksape funding in future years?

   Very Unlikely — Very Likely

9. Will you update and otherwise modify your Woksape software to keep it current for your classes in the future?

   Very Unlikely — Very Likely

10. Please rate the following. Check the box marked N.A. if you had no occasion to use a service.

	Inadequate				Excellent	N.A.
Support from U of MN staff in Project Woksape office						
Response from IBM representatives on campus						
Maintenance support from Engineering Services						
Help with instructional design from Project Assist						
Assistance from the ACSS Micro Group						
Facilities for pilot-testing software						

11. Has the grant and your work on the project enabled any spinoff benefits -- such as additional research funds or computers -- to you, your department, or the University?

    Yes_____ No_____
    If yes, please describe briefly: ____________________

12. If the University received another grant similar to the Woksape grant from IBM, what changes would you suggest in management or support of the grant? ______________________

____

____

____

The following three questions apply to your use of electronic mail on the St. Paul Computing Services (SPCS) IBM mainframe, using PROFS and Bitnet.

13. How many times have you used PROFS and/or Bitnet on the SPCS mainframe?

_____ 0   _____ 0-10   _____ 10-50   _____ 50 or more

14. If you did not use PROFS regularly, what are the reasons for that? (Check all that apply.)

_____ Already had an account on another system
_____ Tried a few times, but could not log in, so gave up
_____ Had no modem
_____ Had no modem cable
_____ Couldn't hook up the modem correctly and couldn't get help fixing it
_____ Couldn't figure out how to use PROFS
_____ Didn't know whom to call for help
_____ Didn't have time to learn to use electronic mail
_____ Other (please specify) ______________________

15. How satisfied were you with services provided by SPCS?

☐	☐	☐	☐	☐

Very Unsatisfied   Very Satisfied

16. On the following lines, please add other general comments about Project Woksape. Please add any highlights or comments you would like included in our report to central administration on the benefits or impact of participation in Project Woksape.

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Appendix Two: Index of Investigators

Index of Investigators, cont'd.

Index of Investigators, cont'd.

Index of Investigators, cont'd.

Index of Investigators, cont'd.