SESSION X GENERAL STRATEGIES IN LABORATORY COMPUTING: A SYMPOSIUM

Howard L. Kaplan, *Presider*

A microcomputer-based laboratory: Real-world experience

H. JOHN DURRETT, JR., and CATHERINE ZWIENER

*Center for Automated Systems in Education, Southwest Texas State University
San Marcos, Texas 78666*

This paper discusses current hardware and software in use at the Center for Automated Systems in Education, a project of the department of psychology at Southwest Texas State University. The hardware ranges from inexpensive microcomputers to sophisticated color graphic display systems. The advantages and disadvantages of various systems are considered. Current projects of interest to educators and psychologists are mentioned.

"Why is any psychologist concerned with using a computer?" This is a reasonable question, for when one begins to move away from one's area of expertise, it is likely that many diversions that dissipate energy, waste time, and retard professional goals will be encountered. This is especially true when one begins to explore and use computers in psychological research or instruction. Computers by their very nature require enormous amounts of time for one to learn to use them productively. In addition, computers are usually surrounded by a high priesthood of experienced users with whom the psychologist must interact and communicate. Finally, there are problems of change, as in any complex environment, that cause many projects to be delayed, to be modified, or to become obsolete.

Perhaps the first answer to the question of why a psychologist should be concerned with using a computer comes from the dramatic theoretical changes that have taken place in the field of psychology. There are few who can seriously doubt the impact of the "information processing approach" to studying human cognitive processes and behavior. The underlying foundation for this orientation owes much to current theoretical perspectives about the organization, processes, capabilities, and limitations of modern digital computers. How-

ever, there are several other salient reasons for a psychologist to invest time in learning to use computers for research and instruction. Some of the more apparent reasons are that the computer will allow experimental designs and controls that are not currently possible by any other means. Computers can execute tasks such as real-time simulations and models that simply cannot be done using the printed page or the chalkboard. Furthermore, there is the potential for the computer to actually increase the productivity of both the researcher-educator and the student.

There are, however, serious disadvantages to using computers. Until very recently, they were expensive, had little software available for instructional purposes, and were of such limited capabilities that they could not be justified for use throughout the entire curriculum. Further, much professional time had to be invested in acquiring and using computers, with little or no possibility of professional recognition.

For all of these problems, however, the more serious issue to be resolved is "How is the computer to be used in instruction and research?" For many psychologists, this is the more troublesome problem. Without answering this question, the psychologist is like the student who is eager to collect data but has not quite decided how the data will be used. Many of the articles that regularly appear in *Behavior Research Methods & Instrumentation* can assist the novice in making wise decisions in developing a computer-based psychology laboratory. Many members of the National Conference On the Use of On-Line Computers in Psychology can also assist the beginner. This article illustrates how computers are being used in one typical psychology department.

This material is based upon work supported by the National Science Foundation under Grants 13987 and 8000893. Any opinions, findings, and conclusions or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of the National Science Foundation. For reprints contact John Durrett, Center for Automated Systems in Education, Southwest Texas State University, San Marcos, Texas 78666.

THE CENTER FOR AUTOMATED SYSTEMS IN EDUCATION

Let us now consider some basic hardware and software that are being used in the Department of Psychology's Center for Automated Systems in Education (CASE) at Southwest Texas State University. In June 1979, the department established CASE to explore and develop the computer hardware, software, and courseware resources necessary to support research and instruction in psychology. CASE was also intended to serve as a model of instructional computer usage for other departments at the university. From a modest beginning, CASE has had an expanding research and development role in the department and university.

Timesharing-Based Computing

CASE's first research and instruction efforts were with a device known as the Polytronics "universal response time" (URT)¹ that was used in conjunction with a CRT terminal connected to the central campus computer, a Digital Equipment Corporation (DEC) 10. The device allows reaction time measures of response using timesharing terminal. The computer terminal was used for our implementation of a set of computer programs written by Bewley (1974).² The programs were used to teach cognitive and experimental psychology to undergraduate students. This initial use of computer-based curriculum packages met with modest success. Students were able to complete laboratory assignments and gain some hands-on experience in psychological experimentation. The inexpensive URT device allows a psychologist to explore computer-based instruction and research using existing timesharing computers with minimal investment in hardware and software development. (See Durrett, 1974, for programming techniques that can be used with such devices.)

Inexpensive Microcomputers

These initial experiments provided the motivation to develop a computer facility for use in the department of psychology. Our first departmental computer was a Commodore PET 2001³ that served as a general-purpose system for experimental and instructional needs. This computer, along with the Radio Shack TRS-80⁴ and the Apple II,⁵ is finding its way into many psychology departments. In addition to having the high-level language BASIC, the PET 2001, like these other microcomputers, has a very powerful hardware interface system. The chief advantages of such machines are their low cost, portability, reliability, ease of programming, and flexibility. Limitations include limited storage devices, fixed capabilities, and low speed. With additional hardware, some of these problems can be minimized or eliminated. (See Durrett, 1978, for more information on inexpensive microcomputers such as the PET 2001 and TRS-80; or see Durrett, 1979, for information on the Apple II microcomputer.)

We have used these low-cost machines for teaching BASIC to students in a course on the applications of computers to research and instruction in psychology. The computers have been used to control video output to a large-screen television monitor for group viewing. The computers have been used to control slide projectors and to process responses from button boxes and voice-activated relays. The "jiffy" (1/60-sec) timers have been used for student projects on short-term memory, long-term memory, and reaction time measurement. (There are ways to increase the accuracy of timing. For elaboration of the techniques for use of such devices as tachistoscopes, see Reed, 1979.)

We have acquired or developed programs to perform statistical tests and analyses. These machines have been used for advertising our department at College Day and for an information management system for departmental courses and equipment. We have constructed an analogue-to-digital interface for these microcomputers and have used them to process data from physiological recording and biofeedback equipment.

Finally, the microcomputers have been portable enough for faculty members to move to their offices to "really get some work done." Actually, the portability and fixed capabilities have special appeal, since faculty members can be certain that a system programming staff will not change the operating system overnight and make their programming efforts obsolete.

For about \$1,500, these machines are certainly good investments for any psychology department interested in using computers. We currently have four microcomputers of this type. Cassette tapes and disks are used for external memory, and a special PET 2022 printer is used for output. The PET, TRS-80, and Apple II are the durable "workhorse" computers in our laboratory. We are not overly concerned about where they are located, since they are so resistant to mishandling.

New Opportunities for Research

We have also used the Compucolor II.⁶ This 32K RAM microcomputer has an eight-color display and an integral disk unit. Like almost all of the inexpensive microcomputers, these computers arrive with many game packages. At first, we were concerned about the number of hours our students played games on the computers, but we have now decided to study game playing and problem solving behavior using these packages. Further, the ease and, in some cases, difficulty in using these computers has led to a new research program in the department directed toward the study of the human factors associated with the use of computers for instructional purposes. The game packages have offered a new avenue for research in the area of problem solving using complex visual displays. In the games, an individual is confronted with a problem solving situation and a process control display representing various conditions. We are currently exploring human information process-

ing associated with these complex visual displays.

The advantage of a system such as the Compucolor II is its high capabilities at minimum cost. Two major disadvantages are the limited software available for this machine and problems of reliability in the video circuit section of the microcomputer. We recommend comparison with an Apple II with similar features. The Apple II relies on a conventional television monitor for output. (See Durrett, 1979, for more information on color display systems.)

Advanced Microcomputers and Their Application

The most powerful hardware we are using for research and instruction is the Chromatics CG 1599 color graphics microcomputer system.⁷ This device has allowed us to begin a major research program on the cognitive processes associated with comprehension and understanding of complex visual graphics. The Chromatics allows the presentation of high-resolution graphics in 256 different colors at real-time speeds. A special clock and blanking circuitry makes it an excellent general-purpose cognitive research instrument. Further, it can drive several color monitors and process input from several response stations. A current research project is studying the human information processing associated with the instructional use of colors (Durrett & Zwiener, 1981). Also, we have had art students exploring the creative possibilities of color video display systems.

The advantages of the Chromatics are its extensive capabilities, high reliability, programming flexibility, extensive software and firmware, color graphics, disk storage, and a user-modifiable operating system. One disadvantage is its moderately high cost, resident programming language, and 32K RAM limited memory.

Minicomputers for Instruction and Research

The newest additions to our laboratory are the TERA 8510/a LSI-11-based minicomputers.⁸ These machines have been used to implement a new cognition and perception package written by Levy, Fisher, and Griggs (1979). The TERA has graphic capabilities that allow us to present to subjects graphic stimuli that would not be possible with other computer display devices. The TERA also has user-definable character sets. Although it has a moderately high cost (\$6,000), features such as multiuser BASIC, PASCAL, and FORTRAN make its cost comparable to that of low-cost microcomputers on a per-user-station basis.

One of the best features of the TERA is a word processing program that is a part of the PASCAL language editor. This program was an immediate success with staff, faculty, and students. Many have been writing laboratory reports and letters using the editor and a Diablo hard-copy printer.⁹ The TERA costs half as much as compatible word processing systems and is capable of many of the operations performed by such machines. Special parallel, serial, and video inter-

faces allow the processing of information from and transmission of information to specialized devices. The computer can be shared by as many as four terminals under multiuser BASIC. The ability to present graphics from the video display over standard video monitors and the ability to videotape-record such output are added advantages of the TERA.

Specialized Input/Output Devices

Other hardware that provides additional capabilities for the laboratory is a Houston Instruments HI-PAD digitizer and HI-PLOT plotter. These devices allow students to enter complex graphic stimuli, such as maps, into the computer. Students then are able to study the information processing associated with visual graphics under carefully timed and controlled conditions. The plotter also serves as a valuable stimulus creation device as well as an instructional tool. A student-written program allows the plotter to serve as a general-purpose hard-copy graphic output device (Durrett & Liberty, Note 1). Graphics can be used to illustrate papers and make transparencies and slides. (See Durrett, 1980, for more information on application of plotters and digitizers.)

CONCLUSION

Although we are just beginning to utilize computers in classroom instruction and research, we are finding many new areas for instructional application and new avenues of research that are made possible by the use of micro- and minicomputers. Furthermore, the availability of low-cost computer hardware has changed the way we think about and conduct psychological research. The computers have made an inactive faculty become more involved in research. Further, student interest in computers has been increased by their practical use and ease of access. The future of many psychology department programs may one day depend on the power of computing.

REFERENCE NOTE

1. Durrett, H. J., Jr., & Liberty, L. *A BASIC software package for inexpensive plotters*. Manuscript in preparation, 1981.

REFERENCES

- BEWLEY, W. Cognitive psychology: A computer-based approach. Wentworth, N.H: COM Press, 1974.
- DURRETT, H. J., JR. A multiprogram approach to real-time experimentation. *Behavior Research Methods & Instrumentation*, 1974, 6, 259-262.
- DURRETT, H. J., JR. Inexpensive microcomputer systems for research and instruction: A dream or reality? *Behavior Research Methods & Instrumentation*, 1978, 10, 345-351.
- DURRETT, H. J., JR. Color display systems: The state of the art. *Behavior Research Methods & Instrumentation*, 1979, 11, 127-130.
- DURRETT, H. J., JR. Inexpensive plotters and digitizers for

- research and instruction. *Behavior Research Methods & Instrumentation*, 1980, **12**, 244-247.
- DURRETT, H. J., JR., & ZWIENER, C. A. Human information processing and color displays. *Proceedings of Southcon/81*, 1981, **Session 12**, 1-7.
- LEVY, M., FISHER, I. S., & GRIGGS, R. A. *Laboratory in cognition and perception*. Iowa City, Iowa: CONDUIT, 1979.
- REED, A. Microcomputer display timing: Problems and solutions. *Behavior Research Methods & Instrumentation*, 1979, **11**, 572-576.

NOTES

1. Polytronics, Methodist Hill, Lebanon, New Hampshire 03766.
2. These programs are available from CONDUIT, P.O. Box 388, Iowa City, Iowa 52240.
3. Commodore Corporation, 901 California Avenue, Palo Alto, California 94304; (415) 326-4000.
4. Radio Shack, Inc., 700 One Tandy Center, Fort Worth, Texas 76102.
5. Apple Corporation, 10260 Bandley Drive, Cupertino, California 95014; (408) 996-1010.
6. Compucolor, 5965 Peachtree Corners East, Norcross, Georgia 30071; (404) 449-5961.
7. Chromatics, 2558 Mountain Industrial Blvd., Tucker, Georgia 30260; (404) 493-7000.
8. Terak, 14151 N. 76th Street, Scottsdale, Arizona 85260; (602) 998-4800.
9. Diablo Systems, Inc., 24500 Industrial Blvd., Haywood, California 94545; (415) 786-5000.