DOCUMENT RESUME

ED 323 993 IR 014 644

AUTHOR	Collis, Betty
TITLE	The Best of Research Windows: Trends and Issues in Educational Computing.
INSTITUTION	International Society for Technology in Education, Eugene, OR.
REPORT NO	ISBN-0-924667-66-4
PUB DATE	90
NOTE	105p.
AVAILABLE FROM	International Society for Technology in Education, 1787 Agate Street, Eugene, OR 97403-9905.
PUB TYPE	Information Analyses (070) -- Reference Materials - Bibliographies (131)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Annotated Bibliographies; *Computer Assisted Instruction; Computer Science Education; *Computer Software; Cost Effectiveness; *Curriculum Development; Databases; *Educational Trends; Elementary Secondary Education; *Media Research; Microcomputers; Postsecondary Education; Preschool Children; Sex Differences; Teacher Attitudes

ABSTRACT

This document provides: (1) a synthesis of more than 180 research studies cited in the "Research Windows" column that appeared in "The Computing Teacher" journal between 1985 and 1989, and (2) reprints of the columns themselves. In the synthesis section the studies are grouped into five general categories with various subheadings containing bibliographic references for that specific topic followed by a brief discussion. The categories are: (1) curriculum-related instructional support, i.e., the impact of computers in the traditional academic subject areas of language arts, mathematics, and science; (2) computer impact on other learning, with subtopics on database usage, preschool children and computers, Logo, programming (non-Logo), and computer science instruction; (3) software, which includes evaluation and design features such as graphics, types of feedback, and computer-controlled versus student-controlled issues; (4) teacher-focused studies, which include surveys of teachers' attitudes, issues related to teacher training, and factors affecting implementation of computers in the classroom; and (5) other topics, including cost-effectiveness studies, research summaries, and gender and computer use. A brief summary of overall trends concludes this section. Section two reproduces the actual "Research Windows" columns which are referenced in the first section. (DB)

About the Author

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ISBN 0-924667-66-4
Published By ISTE

THE BEST OF RESEARCH WINDOWS:
Trends and Issues in Educational Computing

BY BETTY COLLIS

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The Best of Research Windows:
Trends and Issues in Educational Computing

From 1985 to 1989, I wrote the *Research Windows* column in *The Computing Teacher* journal published by the International Society for Technology in Education (ISTE). The purpose of the column is to identify well-done research studies that have particular relevance to the classroom teacher. I reviewed 180 studies, but I read and evaluated many more in order to select those 180. What are some of the trends that emerged through these four years of research summaries? How can these trends inform teachers who are using computers in their classroom?

I first consider the studies in various groupings, and then I will conclude with some overall comments. The groupings are somewhat arbitrary, as many studies can be classified in more than one way.

My methodology for extracting trends and issues in these studies is not quantitative. Many of the studies do not have the necessary characteristics for a quantitative meta-analysis. More than this, the trends that I see as particularly valuable in a study are often not those that were specifically described by a score with a mean and standard deviation. I chose a quite subjective approach—I read and considered all the studies carefully, and on the basis of this and my other experience with synthesizing research, I extracted what I thought were major points and trends.

I know this methodology has weaknesses, the chief of which is that it rests on one person's opinion. However, I provide full references to the original studies. Those who wish to compare their synthesis of a set of articles to mine can do so. The actual *Research Windows* follow in the second section of this book. Occasionally I cited a study because, in my opinion, it highlights an important issue in the area. This is not to say that other studies not specifically cited here do not have important characteristics; only that I selected studies that I think best elaborate a trend or consistent problem in an area. Also, this synthesis does not attempt to cover all aspects of the studies. It only covers the aspects that I believe most relate to current important issues in the field.

The synthesis has the following sections:

- **Curriculum-Related Instructional Support**
  - Language Arts
  - Mathematics Curriculum
  - Science
- **Computer Impact on Other Learning Focuses**
  - Database Usage
  - Preschool Children and Computers
  - Logo
  - Programming (non-Logo)
  - Computer Science Instruction
- **Software**
  - Software Evaluation
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- **Teacher-Focuses Studies**
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- **Other Topics**
  - Gender and Computer Use
  - Research Summaries
  - Cost-effectiveness Studies
  - Miscellaneous Studies
- **Summary of Overall Trends**

Curriculum-Related Instructional Support

First I discuss studies that relate specifically to the impact of using computers in the traditional subject areas; in particular, language arts, mathematics, and science. The focus of these studies is how computer use can improve the learning experience with regard to curriculum objectives in these subject areas.

Language Arts

Word processing. With language arts, the largest single group of studies (15 in all) relates to word processing. These word processing studies can be categorized around three general focuses.

- **Impact of word processing on various aspects of writing performance:**

Borgh, K. & Dickson, W.P. (1986, April). *The effects on children's writing of adding speech synthesis to a word processor.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco. See page 63.

Daiute, C. (1986, June). *Instrument and idea: Some effects of computers on the writing process.* Paper presented at NECC '86, San Diego. See page 39.

Haas, C. & Hayes, J.R. (1986). "What did I just say?" Reading problems in writing with the machine. *Research in the Teaching of English,* 20(1), pp. 22-35. See page 39.

Haas, C. (1988, April). *How word processing affects planning in writing: The impact of technology.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 77.

Kurth, R.J. (1987). Using word processing to enhance revision strategies during student writing activities. *Educational Technology,* 27(1), pp. 13-19. See page 51.

Levin, J.A., Riel, M., Rowe, R.D. & Boruta, M.J. (1984). Muktuk meets Jacuzzi: Computer networks and elementary school writers. In S.W. Freedman (Ed.), *The acquisition of written language: Revision and response.* Hillsdale, NJ: Ablex. See page 31.

MacGregor, S.K. (1986, June). *Computer assisted writing environments for elementary students.* Paper presented at NECC '86, San Diego. See page 39.

Peacock, M. (1988). *Handwriting versus word processed print: An investigation into teachers' grading of English language and literature essay work at age 16+.* Journal of Computer Assisted Learning, 4, 162-172. See page 90.

Porter, R. (1987). *A Report on the Project "Word Processing, the Writing Process, and Revision Strategies in Young Children."* Unpublished manuscript, Macquarie University, New South Wales, Australia. See page 61.

Wolf, D.P. (1985). Flexible texts: Computer editing in the study of writing. In E.L. Klein (Ed.), *Children and computers* (pp. 37-53), New Directions for Child Development, no. 28. San Francisco: Jossey-Bass. See page 26.

- **Influence of the teacher on the impact of word processing**

Baer, V.E.H. (1987). *Computers as composition tools: A case study of student attitudes.* Paper submitted for publication. See page 64.

Dalton, B.M., Morocco, C.C. & Neale, A.E. (1988, April). *"I've lost my story!" Mastering the machine skills for word processing.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 56.

- **Strategies for teaching word processing skills**

Cortese, J.G. (1988). *Testing two methods of instruction to successfully execute introductory steps of Word Perfect.* Unpublished report, Montana College of Mineral Science and Technology, Butte, Montana. See page 85.

Dalton, B.M. Moracco, C.G., & Neale, A.E. (See above section).

Wagner, W.G., O'Toole, W.M., Kazelskis, R. (1985). Learning word-processing skills with limited instruction: An exploratory study with college students. *Educational Technology, XXV*(2), 26-28. See page 19.

The major trends coming from these studies are that students like word processing, they like writing better with word processing than they do by hand, and even young children can be comfortable users of word processing. However, it is also clear that students are not apt to make effective use of the word processing without explicit instruction about writing-process skills, such as revision, away from the computer.

Wolf's study is particularly useful. He identified the tendency of young writers to have only a limited "window" on their writing; and what they see as connected text when using a word processor, and concluded that students must be taught "to think in terms of large-scale changes and to make such changes with an eye on the resulting ripples of effects throughout their texts."

Another useful study is Daiute's. She carefully studied the differences in errors students make with word-processed and hand-written text, and found more punctuation errors, sentence fragments, and "empty words" with word-processed text. She notes that the punctuation errors may be related to keyboarding difficulties, but, more interestingly, she suggests that "empty words" may occur because word processing resembles oral speech more than does traditional writing. The implications of this, both with respect to comparing and assessing the two modes of writing, but also with respect to long-range writing development, are important.

More generally, most of the studies support, either implicitly or explicitly, the influence of the teacher and the teacher's instructional decisions on any impact of word processing on writing. We know that it is not enough to give writers a potentially powerful tool and hope that this will improve the quality of their writing and the process by which they write. One study that both reinforces this point and also gives excellent practical strategies to teachers is the one by Dalton et al. In this study, the researchers note the amount of time that young word processing users and their teachers spend on various aspects of the mechanics of using the word processing system and comment that this is time not being spent on the process and content of writing itself. They then indicate ideas for integrating gradual word processing skill development within language and writing lessons.

Keyboarding. Four studies relate to keyboarding from the context of its impact on the use of word processing for writing skill development:

> Gerlach, G.J. (April, 1987). *The Effect of Typing Skill on Using a Word Processor for Composition.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. See page 68.
>
> Phillips, S.E. (1986). *Computer Readiness in Grade One.* Unpublished master's thesis, University of Victoria, Victoria, British Columbia. See page 49.
>
> Stoecker, J.W. (1985). *Touch-typing instruction in the elementary school: Current practice, a proposed research-based inservice program.* Unpublished doctoral dissertation, University of Oregon. See page 45.
>
> Warwood, B., Hartman, V., Hauwiller, J. & Taylor, S. (1985). *A research study to determine the effects of early keyboard use upon student development in occupational keyboarding.* Research report prepared for the Office of Public Instruction, Helena, Montana. See page 49.

The general conclusion of these studies is that even young children can develop reasonably functional keyboarding skills, sometimes with direct instruction, but also just through regular keyboard use. Phillips' study tested children at the beginning and end of Grade 1. All the children showed a significant improvement in speed and accuracy in terms of locating specific keys on the keyboard. Children who had regular access to computer use during Grade 1 improved even more than did other children, who apparently only had access to keyboards at home or through the general presence of keyboards in our culture.

The value of thorough instruction relative to keyboarding skills for younger children might even be questioned. One study, Warwood et al., found that keyboard skills acquired through giving fourth graders formal touch-typing instruction quickly faded away when the lessons finished. Gerlach's study also involved Grade 4 children and found that those who had had extensive typing instruction performed no differently in terms of length of essays, number or type of revisions, and attitudes toward writing and word processing than did children who used only a hunt-and-peek approach when both groups were given the opportunity to use word processing for writing.

Writing to Read. Three studies related to the *Writing to Read* (WTR) system for early language development:

> Collis, B. Ollila, L. & Muir, W. (1987). *Interim report on the Victoria Installation of Writing to Read.* Publication Number 11. University of Victoria-IBM Canada Software Engineering/Education Cooperative Project, Victoria, B.C. See page 64.
>
> Ollila, K. (1987). *A comparison of the effectiveness of the computer-based Writing to Read program with a more traditional language arts program with respect to their impact on the development of writing skills at the Grade 1 level.* Unpublished master's thesis, University of Minnesota. See page 63.
>
> Zurn, M.R. (1987). *A Comparison of Kindergartners' Handwritten and Word Processor-Generated Writing.* Unpublished doctoral dissertation, Georgia State University, Atlanta, GA. See page 68.

The studies agreed in that they all found some impact on writing development, but not when measured by holistic criteria (a different result than that obtained by the well-known ETS evaluation). Similar to the ETS results, however, was the lack of any particular impact of the system on reading development. Some points of criticism of the overall system were presented. Zurn's study made an interesting observation. She noted that the WTR children in her sample showed no tendency to make use during their free writing of the so-called cycle words stressed by the system in its ongoing phonics drills. This supports the criticism, which has been made by a number of early language specialists, that the words chosen for emphasis in WTR are largely irrelevant to the target children in their natural use of language.

Computer-supported language experiences for students with learning difficulties. Seven studies looked at language-skill development in language-disabled or disadvantaged students:

Chrosniak, P.N. & McConkie, G. (1985, April). *Computer aided reading with reading discouraged children*. Paper presented at the annual meeting of the American Educational Research Association, Chicago. See page 31.

Collis, B. (1988). *An Evaluation of the Program II Severely Learning Disabled (Elementary) Computer Project, Greater Victoria School District #61*. Victoria: University of Victoria Report. See page 68.

Grisham, J.D., & Rubin, D. (1985). *Computerized Vision Training*. First Annual Report, American Institute for Research in the Behavioral Sciences, P.O. Box 1113, 1791 Arastradero Road, Palo Alto, CA 94302. Chrosniak, P.N. & McConkie, G. (1985, April). See page 37.

Harper, J.A. & Ewing, N.J. (1986). A comparison of the effectiveness of microcomputer and workbook instruction on reading comprehension performance of high incidence handicapped children. *Educational Technology*, 26 (5), pp. 40-45. See page 44.

Ward, R., Lindley, P., Rostron, A., Sewell, D. & Cubie, R. (1985). Computer-assisted learning and deaf children's language: Using the language and thought software in a hearing-impaired unit. *Journal of the British Association of Teachers of the Deaf, 9(3), 61-66*. See page 64.

Lancy, D.F., & Hayes, B.L. (1988). Interactive fiction and the reluctant reader. *English Journal*, November, 42-46. See page 89.

MacArthur, C.A., Haynes, J.A., Melouf, D.B., & Harris, K. (1987, April). *Computer assisted instruction with learning disabled students: Achievement, engagement, and other factors related to achievement*. Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. See page 72.

These studies deal with a wide variety of language problems, some of them involving physical handicaps, others relating to "reading discouraged," severely learning disabled, or reluctant-reading students. In general, the results are positive. Students seem to stay on task longer than they would have been expected to and positive learning gains were reported in most of the studies. In some of the studies special hardware and software situations were being tested, while in four studies "off-the-shelf" software is used. Lancy's work with reluctant readers and interactive-fiction software is a good example of capitalizing on the potential in existing software for better motivation of at least some students with histories of reading discouragement.

Computer-mediated-communication. Three studies looked at what might be called computer-mediated-functional communication.

Riel, M. (1984). The Computer Chronicle Newswire: A functional learning environment for acquiring literacy skills. *Journal of Educational Computing Research, 1* (3), 317-337. Riel, M. (1984).

Stroble, E.J. (1988, April). *A look at writers' comments shared on computer screens: Can electronic mail facilitate peer group response?* Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 87.

Zimmerman, D.P. (1987). Effects of computer conferencing on the language use of emotionally disturbed adolescents. *Behavior Research Methods, Instruments, & Computers*, 19(2), 224-230. See page 72.

The Zimmerman study and Stroble study both involved telecommunications, one among disturbed adolescents and the other with a group of teachers in training. All the studies relate to the use of the computer as a way to motivate and deliver cooperative communication experiences. The results are generally positive. In the study with disturbed adolescents, it was found that telecommunications, compared with face-to-face communications, did not differ in the range of words used or in the frequency of words used in various contexts. What did differ, however, was that these students felt a lower level of "experienced tension or stress" when using the computer for communicating with each other than they did during face-to-face encounters. Also, they were more likely to express their feelings or talk about interpersonal issues through the computer than in person. Stroble found no differences in the quality or frequency of certain types of communication when student teachers communicated in a group setting or through electronic mail. She argues that this could be promising support for telecommunications as a cost-effective alternative educational tool in situations where students find it difficult to assemble together for group sessions. Stroble also notes, however, the difficulties in effectively managing or moderating an electronic conversation.

Computer use and new vocabulary. One final study remains in the language arts category.

> Dreyer, L.G., K.R. & Boehm, A.E. (1985) Sight words for the computer age: An essential word list. *The Reading Teacher*, 39(1), 12-15. See page 28.

This research is interesting because it identified some of the many new vocabulary words that occur in the context of using educational software, but are not yet systematically studied in school because they are not part of traditional reading lists. The authors of the research argue that teachers should be more attentive about teaching the meanings, and sometimes the spellings, of these words to children to prevent frustration when the children are supposed to react to the words while using software.

Mathematics Curriculum

Eleven studies examined CAI in mathematics drill:

> Bailey, B. (1984), 'Tanker': A small piece of evaluation. *Micro-scope*, 11, 13-14. See page 24.

> Campbell, D.L., Peck, D.L., Horn, C.J., & Leigh, R.K. (1987). Comparison of computer-assisted instruction and print drill performance. *Educational Communication and Technology Journal* (ECTJ), 35(2), 95-103. See page 80.

> Fuson, K.C., & Brinko, K.T. (1985). The comparative effectiveness of microcomputers and flash cards in the drill and practice of basic mathematics facts. *Journal of Research in Mathematics Education*, 16(3), 225-232. See page 54.

> Griswold, P.A. (1984). Elementary students' attitudes during 2 years of computer-assisted instruction. *American Educational Research Journal*, 21(4), 737-754. See page 23.

> Hativa, N. (1988). CAI versus paper and pencil: Discrepancies in students' performance. *Instructional Science*, 17, 77-96. See page 82.

> Hativa, N. (1988). Computer-based drill and practice in arithmetic: Widening the gap between high- and low-achieving students. *American Educational Research Journal*, 25(3), 366-397. See page 90.

> Human Resources Research Organization, (1986). *Dolphin curricula in Washington, D.C.* 1100 South Washington St., Alexandria, VA 22314-4499. See page 47.

> Mevarech, Z.R., & Rich, Y. (1985). Effects of computer-assisted mathematics instruction on disadvantaged pupils' cognitive and affective development. *Journal of Educational Research*, 79(1), 5-11. See page 29.

> Mevarech, Z.R., & Ben-Artzi, S. (1987). Effects of CAI with fixed and adaptive feedback on children's mathematics anxiety and achievement. *The Journal of Experimental Education*, 56(1), 42-46. See page 80.

> Morris, J.P. (1983). Microcomputers in a sixth-grade classroom. *The Arithmetic Teacher*, 31(2), 22-24. See page 43.

All of but one of these students involve younger children and 8 of the 11 relate to computer-delivered drill and practice. Eight of the studies (Bailey, Fuson & Brinko, Henderson et al., Human Resources Research Organization, Griswold, Mevarech & Ben-Artzi, Mevarech & Rich, and Morris) show a positive impact, both in performance and attitude, following the computer use. Five of the studies stressed the development of stronger self-concepts in mathematics as an important outcome of their research (Griswold, Henderson et al., Human Resources Research Organization, Mevarech, Ben-Artz and Rich). These effects were emphasized in less-advantaged samples in three of these studies. (Griswold, Mevarech & Rich, and Human Resources Research Organization.) Morris showed a positive gain in understanding concepts of coordinate graphing for children who had played some simple games involving graphing skills.

Only three of the studies, however—Fuson & Brinko, Hativa (*Instructional Science*), and Mevarech & Artzi—appeared to make an attempt to carefully control variables when comparing computer-delivered drill and practice with paper-and-pencil drill (or flashcards) covering the same materials. These studies found either no advantage for the computer-delivered materials or a disadvantage.

In general, I feel the studies that consider many aspects of child-computer interaction, such as the three listed above, provide a more critical insight than do those that rely more on group mean gain scores (the sorts of data that make studies appropriate for quantitative meta-analysis). Hativa's work, for example, is particularly helpful with respect to the differential impact of CAI drill in elementary mathematics on lower-achieving and higher-achieving students. Many have argued that computer drill may offer a real opportunity for the slower learner to "catch up" to his or her peers because of the special features of computer-delivered drill, such as its "patience," immediate feedback, and potentially fine-tuned management of student practice. Hativa's two studies, however, suggest that features of the software design may generate a wide difference in the impact of the computer drill experience, but with higher-achieving children getting the benefit and lower-achieving children falling even further behind.

The one study in this set that relates to older students is Henderson et al. In this research, junior secondary students interacted with a computer-driven videotape that focused on fractions and prime factors. However, besides the mathematics content, the researchers were also interested in improving their female students' attitudes about themselves as users of mathematics. Female models were used extensively in the videotapes, and the visuals stressed females being persistent at mathematics and attributing their performance in mathematics to their own efforts rather than to factors beyond their control. There were positive results, both in terms of subject matter and of transferring the attitudes depicted in the videotapes to the subjects.

Science

Research relating to science has the following focuses:

- Simulations
- Microcomputer based laboratories (MBL's)
- Problem-solving software
- Drill software

Science simulations. Thirteen studies relate to using simulations to teach science concepts:

DeClercq, B., & Gennaro, E. (1986, March). *The effectiveness of supplementing the teaching of the volume displacement concept with use of an interactive computer simulation*. Paper presented at the 59th Annual Conference of the National Association for Research in Science Teaching, San Francisco. See page 41.

Erkens, G., & Barnard, Y.F. (1988, April). *Computer simulation of information exchange during cooperative problem solving*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 87.

Finley, F.N., (1986, March). *Learning from science computer simulations*. Paper presented at the 59th Annual Conference of the National Association for Research in Science Teaching, San Francisco. See page 41.

Johnson, R.T., Johnson, D.W., & Stanne, M.B., (1986). Comparison of computer assisted cooperative, competitive, and individualistic learning. *American Education Research Journal*, *23*(3), 382-392. See page 49.

Reed, J.H., & Judkins, J., (1986). Evaluation of a holistic CAI system in introductory chemistry. *Journal of Computers in Mathematics and Science Teaching*, *6*(1), 21-27. See page 53.

Rivers, R.H., & Vockell, E., (1987). Computer simulations to stimulate scientific problem solving. *Journal of Research in Science Teaching*, *24*(5), 403-415. See page 57.

Rowland, P., & Stuessy, C.L., (1987, April). *Effects of modes of computer-assisted instruction on conceptual understanding and achievement of college students exhibiting individual difference in learning: A pilot study*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Washington, DC. See page 73.

Shaw, E.L., Jr., & Okey, J.R. (1985, April). *Effects of microcomputer simulations on achievement and attitudes of middle school students*. Paper presented at the National Association For Research in Science Teaching Annual Meeting, French Lick Springs, IN. See page 21.

Stevens, S.M. (1985, April). *Surrogate laboratory experiments: Interactive computer/videodisc lessons and their effect on student's understanding of science*. Paper presented at the 58th Annual Conference of the National Association for Research in Science Teaching, French Lick, Indiana. See page 41.

Waugh, M.L. (1986, June). *The effect of teacher involvement on student performance in a computer-based science simulation*. Paper presented at NECC '86, San Diego. (Dr. Waugh is at the University of Illinois, 1310 South Sixth Street, Champaign, IL). See page 40.

Woodward, J., Carnine, D., & Gersten, R. (1988). Teaching problem solving through computer simulations. *American Educational Research Journal*, *25*(1), 72-86. See page 77.

Zietsman, A.I., & Hewson, P.W. (1986). Effect of instruction using microcomputer simulations and conceptual change strategies on science learning. *Journal of Research in Science Teaching*, *23*(1), 27-39. See page 41.

The science simulation studies are encouraging—students can learn well with this type of software. In some of the studies, the students' performance after the use of a simulation was no different than that of students who had used traditional hands-on activities. This leads a number of researchers to the conclusion that simulations can substitute for some laboratory experiences, a conclusion that can be encouraging if the lab experiences are expensive or unfeasible to manage.

As was the case with word processing, however, the research makes it clear that it is not good enough to simply have the student work through a simulation. Six of the studies emphasize the improved impact that comes from some sort of "intelligent" support or interaction with the student with respect to the use of the simulation. In three studies, this sort of remediation or strategy provision was incorporated into the courseware (Rivers & Vockell, Zietsman and Henson, and Zietsman & Henson) and in each case resulted in better student learning. Three of the studies (DeClercq & Gennano, Finley, and Woodward, et al.) show the importance of instructional decisions made by the teacher on eventual student learning from a science simulation. The last of these studies is particularly interesting, in that it relates to learning-disabled secondary school students using a simulation about health care. With the help of specific guidance before, during, and after the simulations, these students were able to perform as well or better than mainstream students in the same school on follow-up tests of understanding and transfer of problem-solving strategies.

MBL's. Five studies involve the use of microcomputer-based laboratories in science:

Berger, C.F. (1986, April). *Misconceptions and thinconceptions of teachers using microcomputer based laboratories*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco. See page 55.

Brassell, H. (1987, April). *The role of microcomputer-based laboratories in learning to make graphs of distance and velocity*. Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. See page 66.

Linn, M.C. (1986, April). *Learning more-With computers as lab partners*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco. See page 55.

Mokros, J.R., & Tinker, R.F. (1987). The impact of microcomputer-based labs on children's ability to interpret graphs. *Journal of Research in Science Teaching, 24*(4), 369-383. See page 57.

Nachmias, R., & Linn, M.C. (1987). Evaluations of science laboratory data: The role of computer-presented information. *Journal of Research in Science Teaching, 24*(5), 491-506. See page 66.

The studies involving MBLs are also very encouraging. MBLs can enable the students "to use computers as real scientists do, to collect data in real time as an experiment progresses, display it, save it, and print it for later analysis," (Linn, 1986) and "can increase the accuracy of data collection while alleviating the tedium associated with it." The improvement of graph-interpretation skills can be an important by-product of MBL use (Brassell, and Mokros & Tinker) Associated with this can be an improvement of skills related to the criticism of graphs. Linn has noted this in her work, where she observes the tendency of students to uncritically accept graphic data based on output from the computer, assuming these graphs are always accurate. She notes that it takes time for the students to realize the possible impact of faulty data-gathering equipment and of different decisions about the scaling of graphic displays on the conclusions they make from their data, and that MBLs "provide an opportunity to raise these issues in science class."

From these studies, and others in this area, it appears the the use of MBLs will be a major growth area for computer applications in instruction. However, Berger notes that teacher attitudes and "thinconceptions" about scientific concepts may result in teachers feeling more comfortable using print materials from textbooks to "find the right answer" than they would about using and interpreting the results obtained by MBLs. He notes that this feeling may be increased by the fact that MBL results, unlike textbook problem sets, may not always provide the "right" answers, or even any answers at all. Again, as we have seen in other categories of studies, the critical variable in realizing the potential of this computer application is the teacher.

Other science studies. Of the two remaining studies, one involves the use of drill software and the other problem-solving software:

Seymour, S.L., Sullivan, H.J., Story, N.O., & Mosley, M.L. (1987). Microcomputers and continuing motivation. *Educational Communication and Technology Journal (ECTJ), 35*(1), 18-23. See page 81.

Safrit, M.J., Ennis, C.D., & Magle, F.J. (1988). The use of problem solving skills in computer-aided instruction: An evaluation. *Journal of Computer-Assisted Learning, 4*, 227-243. See page 91.

These two studies both have encouraging aspects. In the Seymour et al. study, students doing the same questions in a paper-and-pencil format, or delivered through the computer, did as well in either format (unlike the previous result in the mathematics section) and felt the work was easier on the computer In the Safrit et al. study, a procedure for evaluating the impact of a program that is supposed to be providing an exercise in scientific problem solving skills is described and then used on a particular program with positive results. This is a particularly interesting study, in that too often we speculate on the impact of computer experiences on various desirable higher-level thinking processes, such as problem solving skills, but do not have a good strategy to test our speculations.

Computer Impact on Other Learning Focuses

Outside of the three major curriculum areas of language arts, mathematics, and science, there have been many studies which relate to the impact of computer use on other focuses of learning, including those that may be interdisciplinary. I have grouped these studies into the areas of database usage, preschool computer usage, Logo, the effects of programming, and computer science instruction.

Database Usage

Six studies focused on database usage:

Beishuizen, J. (1987). CIR: A computer coach for information retrieval. In J. Moonen & T. Plomp (Eds.), EURIT 86: *Developments in educational software and courseware* (pp. 21-27). Oxford: Pergamon Press. See page 71.

Eastman, S.T. (1986). A qualitative study of computers and printouts in the classroom. *ECTJ, 34*(4), 207-222. See page 70.

Edyburn, D.L. (1987). *An Evaluation of the Information Retrieval Skills of Students With and Without Learning Handicaps Using Printed and Electronic Encyclopedias.* Unpublished doctoral dissertation, University of Illinois, Urbana-Champaign. See page 69.

Hedberg, J.G., & Perry, N.R. (1984). *Teacher cognitive styles and selection of computer courseware.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 35.

Reilly, R., & MacAogain, E. (1988). Poorly formed input and miscommunication in natural-language keyboard dialogue. An exploratory study. *Computers in Human Behavior, 4,* 275-283. See page 89.

White, C.S. (1985). *The impact of structured activities with a computer-based file- management program on selected information-processing skills.* Unpublished doctoral dissertation, Indiana University. See page 42.

These studies feature a variety of perspectives, but most attest to the difficulties students may have in asking "good" questions when they have access to a database. Two of the studies focus on search strategies (Beishuizen, and Hedberg & Perry) and another, Reilly & MacAogain on common errors in command entries that people make when trying to interrogate a database. White's study is particularly encouraging in that he found, with a sample of 28 different secondary school classes, that students using database management software and activities to structure use of this software during social studies instruction did better on subsequent generalized tests of the evaluation and use of information than did students who did not use the database software.

Two of the studies, Eastman and Edyburn, relate to students using on-line informational databases. Edyburn found that learning-handicapped students as well as mainstream secondary school students were able to handle different sorts of on-line databases (both with command-driven and menu-driven user interfaces). However, students were more successful when their teachers assigned the search focuses than when they had to generate topics and questions of their own choosing. The Eastman study is particularly good to read because it details the responses of eighth-grade students using an on-line encyclopedia for a three-week period. Anyone who has taught eighth-grade students will recognize the verisimilitude of the case study. The students were more interested in getting a printout than with the quality of the information they found. Students spent considerable time manipulating their printouts, stapling them, and doing other activities that gave the appearance of being at work. In actuality, they were willing to abdicate some of their research responsibilities to the computer, assuming what was in the computer was "enough," as long as their printouts were as long as other students. This study reminds us that students do not necessarily engage in educationally relevant activities even when comfortable with and having ample opportunities to use a resource with considerable educational potential.

Preschool Children and Computers. Six studies focused on preschool children and computer use:

Borgh, K., & Dickson, W.P. (1986). Two preschoolers sharing one microcomputer: Creating prosocial behavior with hardware and software. In P.Campbell & G. Fein (Eds.). *Young Children and Microcomputers*, pp. 38-44. Englewood Cliffs, NJ: Prentice-Hall. See page 47.

Goodwin, L.D., Goodwin, W.L., Nansel, A., & Helm, C.P. (1986). Cognitive and affective effects of various types of microcomputer use by preschoolers. *American Educational Research Journal*, *23*(3), 348-356. See page 49.

Massey, C., & Gelormino, J. (1987, April). *The influence of a math software program on preschoolers' acquisition of mathematics: 'Ruton' in the classroom.* Paper presented at the annual meeting of the American Educational Research Association, Washington DC. See page 70.

McCollister, T.S., Burts, D.C. Wright, V.L., & Hildreth, G.J. (1986). Effects of computer-assisted instruction and teacher-assisted instruction on arithmetic task achievement scores of kindergarten children. *The Journal of Educational Research*, *80*(2), 121-125. See page 52.

Riding, R.J., & Tite, H.C. (1985). The use of computer graphics to facilitate story telling in young children. *Educational Studies*, *11*(3), 203-210. See page 46.

Swigger, K.M., & Swigger, B.K. (1984). Social patterns and computer use among preschool children. *AEDS Journal*, *17*(3), 35-41. See page 37.

The results are all gently positive. Borgh & Dickson and Swigger & Swigger examined social interactions of children in preschool settings with unlimited access to computers. Swigger & Swigger found that about half of the children paid no attention to the computers at all, and the remaining children always came to the computers in pairs or in larger groups. The presence of the computer in the classroom was not seen as altering the already defined social groupings among the children. In the Borgh & Dickson study, pairs of young children interacting with drill-type programs involving the alphabet and counting were audiotaped as they interacted. The conclusions were that the social interactions were positive and "may have greater educational significance than those taking place between the children and the computer."

The other studies looked at the impact of certain particular software packages on learning. In one study, McCollister et al., a particularly interesting result occurred. Higher-ability children seemed to do well with a computer game about number sequences, but lower-ability children did better when they worked with the teacher and used concrete manipulatives. This suggests that the use of computer resources in kindergarten classes might be directed toward higher-ability children, leaving the teacher with more time to interact personally with the other children. What the long-range implications of such an idea are cannot be said.

Logo

Logo, not surprisingly, is well represented in the research studies. There were 12 in Research Windows, plus a summary of Logo studies in the United Kingdom that appeared in another Research Windows citation:

Clements, D.H., & Gullo, D.F. (1984). Effects of computer programming on young childrens' cognition. *Journal of Educational Psychology*, *76*(6), 1050-1058. See page 19.

Clements, D.H., & Natasi, B.K. (1988). Social and cognitive interactions in educational computer environments. *American Educational Research Association Journal*, *25*(1), 87-106. See page 78.

Cohen, R. (1987, April). *Implementing Logo in the grade two classroom: Acquisition of basic programming concepts.* Paper presented at the annual meeting of The American Educational Research Association, Washington, DC. See page 55.

Frazier, M. (1987). *The effects of Logo on angle estimation skills of 7th graders.* Unpublished Master's thesis. Wichita State University. See page 58.

Govier, H. (1988). *Microcomputers in primary education: A survey of recent research* (Occasional Paper ITE/28a/88) Lancaster, U.K. Economics and Social Research Council. See page 82.

Horner, C.M., & Maddux, C.D. (1985). The effect of Logo on attributions toward success. *Computers in the Schools*, *2*(2/3), 45-54. See page 43.

Howe, J. (1985, March). Logo programming and intermediate mathematics. *Computers in Education*, pp. 7-10. See page 27.

Hunter, J., Kemp, T., & Hyslop, I. (1987). Development and evaluation of the "Thinking with Logo" *Curriculum*. Edmonton, Alberta: Alberta Education. See page 73.

Lehrer, R., Guckenberg, T., & Lee, D. (1988). Comparative study of the cognitive consequences of inquiry-based Logo instruction. *Journal of Educational Psychology, 80*(4), 543-553. See page 90.

Louie, S. (1985). *Locus of Control Among Computer-Using School Children.* (Available from NACCIS, 2200 East River Road, Suite 125, Tucson, AZ 85718, $11.95). See page 22.

Mayer, R.E., & Fay, A.L. (1987). A chain of cognitive changes with learning to program in Logo. To appear in the *Journal of Educational Psychology*, 79(3). See page 59.

Plourde, R.R. (1987). The insignificance of Logo - Stop 'mucking around' with computers. *Microscope*, Logo Special Issue, December, 1987, 30-31. See page 71.

Siann, G., & Macleod, H. (1986). Computers and children of primary school age: Issues and questions. *British Journal of Educational Technology, 17*(2), 133-144. See page 43.

Two trends emerge clearly from these studies:

- The teacher and the level of instructional support that surround Logo use are critical variables in influencing the impact of this use.

- Skills acquired in the context of using Logo are not easily transferable, either to particular mathematics insights or to metacognitive gains. The transfer potential is highly influenced by the instructional guidance that the teacher gives students during their work.

Govier comes to the same conclusion in her 1988 summary of British research on Logo. She says, "It appears that Logo skills only generalize when Logo is taught in a way which emphasizes the skills to be learned and encourages children to deliberately look for connections with other work....The discovery learning advocated by Papert is too unfocussed for transfer of learning to occur.... A structured curriculum is essential."

Most of the Research Windows studies were not successful in showing the type of important benefits that many hope will occur from Logo experiences. Also, the better designed and controlled the study, the less likely it is that hypothesized gains occur. A typical result is that children will be tested on a battery of variables, such as fluency, divergent thinking, time spent considering a problem before answering, Piagetian tasks, picture completion, laterality, map reading skills, various mathematics skills and understandings, misconceptions relating to egocentricity, creativity, flexibility of thinking, resolution of conflict, self-direction, rule determination, problem solving, planning skills, learning to learn, or conceptions of the role and nature of errors. (These variables all appear in the Logo studies cited in Research Windows.) Out of all these tests, Logo children will typically show no results in some and some positive results in others. However, the pattern is inconsistent, and what is found in one study is not replicated in the next.

Three of the studies—Cohen, Horner & Maddux, and Mayer & Fay—look closely at specific difficulties young children have with Logo. All indicate that the process of understanding the left and right orientation of the turtle remains obscure for many children despite classroom games and other introductory activities and despite the fact that the children can identify their own left and right sides. Cohen's study is particularly useful in addressing the question of the developmental readiness of young children, second graders in her case, for turtle orientation and for using two-digit numbers as arguments for FD, BK, RT, and LT primitives. Mayer and Fay also do a careful job of documenting commonly occurring specific misconceptions regarding egocentricity.

One of the studies, Clements & Natasi, makes a particularly good contribution with respect to a better understanding of different social interactions in Logo learning experiences that are likely to be correlates of higher-level problem-solving activity. Seven categories of social behaviors as well as eight categories of problem solving behaviors appropriate for Grade 1 and Grade 3 children are defined and illustrated. This type of clarification of variables could make a substantial contribution to the fragmented Logo research activity that continues to go on.

Another trend is clear in the Logo studies—Logo research itself is improving, from a design and analysis perspective. The many limits to generalizability that frequently appeared in earlier Logo "testimonials" are now better controlled. The results show Logo to be a good tool, but not one that most students will use to much advantage on their own or without thoughtful guidance.

Programming (non-Logo)

Eight studies focused on non-Logo programming, not on how to best teach it, but on what impact it may have on other thinking and how different languages may make a differential effect in this respect. The eight studies I have put in this category are:

Brown, S.W., & Rood, M.K. (1984). *Training gifted students in LOGO and BASIC: What's the difference?* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans. See page 35.

Kagan, D.M., & Douthat, J.M. (1984). Writing style, category width, and introductory FORTRAN. *Journal of Research and Development in Education, 18*(1), 7-11. See page 20.

Linn, M.C. (1985). The Cognitive consequences of programming instruction in classrooms. *Educational Researcher, 14*(5), 14-29. See page 22.

Mayer, R.E., Dyck, J.L., & Vilberg, W. (1986). Learning to program and learning to think: What's the connection? *Communications of the ACM, 29*(7), 605-610. See page 43.

Millar, G., & MacLeod, A. (1984). *Microcomputer learning project: Willowcreek School Division.* Planning Service Branch, Alberta Education, 11160 Jasper Avenue, Edmonton, Alberta. See page 33.

Signer, B.R. (1986). An investigative study of possible effects of programming instruction on math anxiety and teacher attitudes toward CAL. *Journal of Computers in Mathematics and Science Teaching, 5*(4), 40-45. See page 50.

Sigurdson, S.E., & Hunka, D. (1985). *Integrating programming into mathematics.* Planning Service, Alberta Education, Devonian Building, West Tower, 11160 Jasper Avenue, Edmonton, Alberta, T5K 0L2. See page 25.

Webb, N.M. (1985). Cognitive requirements of learning computer programming in group and individual settings. *AEDS Journal, 18*(3), 183-194. See page 37.

Studies investigating the impact of programming on problem-solving skill development or on mathematics achievement are much less prevalent now than they were in the early and middle 1980s. The same can be said about studies looking for patterns among correlates of success in programming, or for studies comparing the benefits of different programming languages on various outcome variables. The eight studies reviewed in Research Windows relate to these topics. The results from these studies, like those from the field in general, are inconclusive or disappointing. There is no good, consistent evidence that learning programming has any positive impact on anything else, although different results emerge in different studies. Mayer et al. conclude by saying, "There is no convincing evidence that learning to program enhances students' general intellectual ability, or that programming is any more successful than Latin for teaching 'proper habits of mind.'"

Computer Science Instruction

Finally, six studies focused on aspects of computer science, computer literacy, or programming instruction:

Battista, M.T., & Steele, K.J. (1984). The effect of computer-assisted and computer programming instruction on the computer literacy of high ability fifth grade students. *School Science and Mathematics, 84*(8), 640-658. See page 19.

Connors, J.M. (1987). *Persistence in Computer Science by First-year Students at the University of Victoria.* Unpublished master's thesis, University of Victoria, Victoria, British Columbia. See page 62.

Greer, J. (1986). High school experience and university achievement in computer science. *AEDS Journal, 19*(2/3), 216-225. See page 62.

Linn, M.C., Sloan, K.D., & Clancy, M.J. (1987). Ideal and actual outcomes from precollege Pascal instruction. *Journal of Research in Science Teaching, 24*(5), 467-490. See page 58.

Pintrich, P.R., Berger, C.F., & Stemmer, P.M. (1987). Students' programming behavior in a Pascal course. *Journal of Research in Science Teaching, 24*(5), 451-466. See page 57.

McCormick, D., & Ross, S.M. (1988, April). *Effects of computer access and flowcharting in learning computer programming.* Paper presented at the annual meeting of the American Educational Research Society, New Orleans. See page 78.

The general conclusion of these studies is that students need strong instructional guidance, particularly with respect to developing habits of thorough planning before beginning hands-on coding. Pintrich et al., observed two Advanced Placement computer science classes for two months during the students' computer science class time. Students almost never engaged in any planning behavior, nor did they have discussions on design features or on different strategies for creating and debugging. The "rush-to-program" urge was strong and most class time was spent on running programs, making minor changes, fixing bugs by trial and error, and asking others for help. Linn and her colleagues, observed 14 Advanced Placement computer science classes, and categorized the classes as exemplary, enhanced, or typical based on programming performance. They found that the instructional strategies used by the teachers were what distinguished the classes. Teachers in the "exemplary" classes required their students to plan before logging on significantly more than did teachers in the other groups.

One study, McCormick & Ross, had two interesting findings that may relate to real-world trends in computer science instruction. First, flow charting was seen as having a potentially negative effect on achievement, possibly because its linear logic is not the same as the perspective involved in a top-down, decomposition approach to designing a program; and second, middle- and high-ability students with limited access to computers tended to do better than similar-ability students with more access. The authors speculate that having to share machines may force students to do more planning away from the machine, which ultimately can translate into more thoughtful perspectives.

SOFTWARE

Under the category, "Software," studies relate to software evaluation and to what I call design features of software.

Software Evaluation

Five studies relate to software evaluation:

Callison, D., & Haycock, G. (1987). *A methodology for student evaluation of educational microcomputer software*. Unpublished manuscript, Indiana University. See page 66.

Jolicoeur, K., & Berger, D.E. (1986). Do we really know what makes educational software effective? A call for empirical research on effectiveness. *Educational Technology, 26*(12), 7-11. See page 51.

Jolicoeur, K. & Berger, D.E. (1988). Implementing educational software and evaluation its educational effectiveness: Part II. *Educational Technology, 28*(10), 13-19. See page 88.

Preece, J., & Jones, A. (1985). Training teachers to select educational computer software. *British Journal of Educational Technology, 16*(1), 9-20. See page 20.

Zohar, A., & Tamir, P. (1986). A new instrument to assess the inquiry characteristics of science computer software. *The Journal of Computers in Mathematics and Science Teaching, 6*(1), 44-46. See page 53.

In general, these studies confirm that software evaluation has a large degree of subjectivity involved in it, and that procedures to help teachers be better evaluators need to be developed. Three of the studies—Callison & Haycock, Jolicoeur & Berger (1986), and Jolicoeur & Berger (1988)—document the discrepancies between teachers' and students' impressions of what makes software "good." There are similar inconsistencies among teachers themselves and also among professional reviewers of software. There is also little relationship between software chosen by teachers, at least in one particular study (Jolicoeur & Berger, 1988) and software most associated with improved student learning. The article by Zohar and Tamir is encouraging, in that it presents a new strategy for evaluation of science software in which particular attention is paid to assessing software relative to its potential impact on inquiry skills.

Design Features

There are 19 studies in the category I call "Design Features." The general conclusion that I draw from them is that any design feature will be more helpful to some learners and in certain situations than it will be to others in other situations. By design features I mean options available in a program relative to:

- **Graphics and animation**

  Hale, E.H., & Okey, J.R. (1985, April). *Using computer graphics and animation in testing*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, French Lick, IN. See page 21.

  Reed, S.K. (1985). Effect of computer graphics on improving estimates to algebra word problems. *Journal of Educational Psychology, 77*(3), 285-298. See page 29.

- **Text features**

  Heppner, F.H., Anderson, J.G.T., Farstrup, A.E., & Weiderman, N.H. (1985). Reading performance on a standardized test is better from print than from computer display. *Journal of Reading, 28*(4), 321-325. See page 25.

  Hartley, J. (1987). Designing electronic text: The role of print-based research. *Educational Communications and Technology Journal (ECTJ), 35*(1), 3-17. See page 81.

- **Immediate Feedback**

  Beaulieu, J.E. (1985). *A study of the effects of selected feedback delay intervals upon retention of science material in a computer assisted instructional task with junior high school students*. Unpublished doctoral dissertation, University of Oregon. See page 27.

■ **Computer-controlled vs. Student-controlled Hints, Options, and Remediation**

Tennyson, R.C., Park, O.C., & Christenson, D.L. (1985). Adaptive control of learning time and sequence in concept learning using computer-based instruction. *Journal of Educational Psychology*, 77(4), 481-491. See page 29.

Dalton, D.W., (1988, April). *The effects of cooperative learning strategies on archievement and attitudes during interactive video*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 86.

■ **Personalizing Questions**

Tamborine, R. (1985). Effects of questions, personalized communication style, and pauses for reflection in children's educational programs. *Journal of Educational Research*, 79(1), 19-26. See page 29.

■ **Computer-controlled vs. Student-controlled Hints, Options, and Remediation**

Reinking, D. & Schreiner, R. (1985). The effects of computer-mediated text on measures of reading comprehension and reading behavior. *Reading Research Quarterly*, 20(5), 536-552. See page 31.

Rubincam, I., & Olivier, W.P. (1985). An investigation of limited learner-control options in a CAI mathematics course. *AEDS Journal*, 18(4), 211-116. See page 32.

Carrier, C.A., & Williams, M.D. (1988). A test of one learner-control strategy with students of differing levels of task persistence. *American Educational Research Journal*, 25(2) 285-306. See page 91.

■ **Types of Feedback**

Janke, R.W., & Pilkey, P.J. (1985). Microcomputer diagnosis of whole number computational errors. *The Journal of Computers in Mathematics and Science Teaching*, 5(1), 45-51. See page 35.

Woodward, J., Carnine, D., Gersten, R., Gleason, M., Johnson, G., & Collins, M. (1986). Applying instructional design principles to CAI for mildly handicapped students: Four recently conducted studies. *Journal of Special Education Technology* (at press). See page 45.

■ **Learning Characteristics That Interact With Design Features**

Murphy-Berman, V., Wright, G., & Roseii, J. (1986). Measuring children's attention span: A microcomputer assessment technique. *The Journal of Educational Research*, 80(1), 23-29. See page 49.

Hativa, N. (1987, April). *Differential effectiveness of computer-based drill and practice in arithmetic*. Paper presented at the annual meeting of the American Educational Association, Washington, DC. See page 56.

■ **Targeted Remediation for Reteaching**

Martinak, R., Schneider, B.R., & Sleeman, D. (1987, April). *A comparative analysis of approaches for correcting algebra errors via an intelligent tutoring system*. Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. See page 61.

■ **Interactive Video Design Presentation**

Bunderson, C.V., Baillio, B., Olsen, J.B., Lipson, J. & Fisher, K.M. (1984). Instructional effectiveness of an intelligent videodisc in biology. *Machine Mediated Learning*, 1(2), 175-215. See page 85.

■ **Pretests**

Dalton, D.W., Goodrums, D.A., & Olson, J.R. (1988, April). *The effects of computer-based mastery pretests on learner achievement and motivation*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans. See page 87.

■ **Color**

Hativa, N., & Teper, A. (1988). Differential effectiveness of three color treatments in learning geometric concepts via computer-based teaching. *Journal of Educational Computing Research*, 4(3), 303-320. See page 88.

Hativa's paper is probably a key one in this set, in that it shows in a careful way how various design features can work to one student's advantage at the same time that they work to the disadvantage of another student.

Another overall conclusion to make from this set is that software design is a very complicated business. Designers have much to consider. Probably a major recommendation is that as many options as possible be available within a program relative to design variables such as those listed above, so that different students can interact with the materials in ways that are good for them as individual learners. This is a major positive value of computer-delivered instructional materials; unlike most other mediums, the computer has the capability of having available a wide variety of options to personalize the experience of working with a program. Of course, these options must be available in the software, through some sort of easy user interface, in order to have this positive feature realized in practice.

Teacher-Focused Studies

I group these studies into three categories—surveys of teachers' attitudes and uses of computers, issues related to teacher training, and factors affecting teachers' implementation of computers in the classroom.

Surveys of Teachers' Attitudes and Uses of Computers

Seven of the studies are in this category:

Andelin, J. (1987). *Trends and status of computers in schools: Use in Chapter 1 programs and use with limited English proficient students.* Staff paper, Science Education, and Transportation Program, Office of Technology Assessment, U.S. Congress, Washington, D.C. See page 59.

Becker, H.J. (1987). *Instructional Uses of School Computers (Issue No. 4).* Center for Social Organization of Schools. The Johns Hopkins University. See page 69.

Carey, D.M. (1985). *An investigation of factors that affect elementary school teachers' educational use of computers.* Unpublished doctoral dissertation, University of Oregon. See page 33.

Mokros, J.R., & Russell, S.J. (1986). Learner-centered software: A survey of microcomputer use with special needs students. *Journal of Learning Disabilities, 19*(3), 185-190. See page 7..

Norris, C.M., & Lumsden, B. (1984). Functional distance and the attitudes of educators toward computers. *T.H.E. Journal,* pp. 129-132. See page 23.

Reid, M.I. (1986, May). *Male and female science teachers' use of microcomputers.* Paper presented to the World Congress on Education and Technology, Vancouver, British Columbia. See page 37.

Thormann, J., & Gersten, R. (1985). *Microcomputer use in special education: An empirical investigation of teachers' perception.* Manuscript submitted for publication. See page 23.

These studies generally make the same observation—although teachers support the value of computer use in education, they are not yet making much use of computers themselves outside of the context of computer literacy and computer science classes. Becker's study on the use of computers in mathematics and science instruction is particularly well known in this respect.

Two of the studies relate to special education (Mokros & Russell, and Thormann & Gersten) and another to disadvantaged and "limited English proficient" students (Andelin). These studies also find relatively little impact of computers in these areas in terms of actual practice. The Mokros and Russell study points out that word processing is being used by a growing number of special education teachers (27% of those surveyed), but it is primarily used for "mechanical error correction" Furthermore, they note in their survey of 50 U.S. school districts that, "Not one special education teacher reported receiving training on how to integrate educational software into the curriculum." Lack of appropriate teacher training is often cited as a factor in teacher non-utilization of school computers.

Teacher Training

Five studies relate to teacher training:

Ellis, J.D., & Kuerbis, P.J. (1985, April). *Development and validation of essential computer literacy competencies for science teachers.* Paper presented at the annual meeting of the Association for Research in Science Teaching, French Lick Springs, Indiana. See page 21.

Cooper-Shoup, S., Farris, P.J., & Higgins, J.E. (1985). *A comparison of computer literacy delivery systems at the preservice teaching level.* Unpublished manuscript, Northern Illinois University, DeKalb, Illinois. See page 34.

Dickson, M., Franklin, J., & Hill, A. (1987, June). *Attitudinal changes through computer conferencing.* Paper presented at the Second Symposium on Computer Conferencing and Allied Technologies, University of Guelph, Guelph, Ontario. See page 70.

Fuchs, L.S. (1987, April). *Effects of computer-managed instruction on teachers' implementation of systematic monitoring programs and student achievement.* Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C. See page 56.

Stecher, B.M., & Solorzana, R. (1987). *Characteristics of effective computer in-service programs.* Report prepared for the Educational Testing Service, 2 North Lake Avenue, Suite 510, Pasadena, CA, 91101. See page 67.

There are, of course, many different issues with respect to teacher training for computers in education use. One problem is content. The studies of Ellis & Kuerbs and Stecher & Solorzana relate to this. The former focuses on appropriate content for science teachers and the latter, more generally, stresses the value of content that relates inservice experiences directly to ongoing classroom practice and curriculum issues.

Another major issue is the delivery strategy. Two of these studies examined innovative delivery strategies—self-instruction courses (Cooper-Shoup et al.) and teleconferencing (Dickson et al.). Both strategies were effective.

Still other issues relate to implementation within the particular inservice setting. Stecher and Solorzano's study is particularly helpful here. These researchers identified 50 exemplary computer related inservice programs in the U.S. and examined eight of them. They found no common procedure for inservice. However, all shared the feature of lesson-related handouts and materials relating directly to classroom applications, and all realized the importance of providing teachers with adequate personal access to computers in their own schools.

Helping Teachers with Implementation Problems

Seven studies focus on implementation issues—problems that make computer use in education difficult or unfeasible for the teacher:

Van den Akker, J.J. (1988). The teacher as learner in curriculum implementation. *Journal of Curriculum Studies, 20*(1), 47-55. See page 89.

Beaver, J.F. (1988). *A national search for quality: An examination of high-quality elementary school instructional computing programs.* Unpublished doctoral dissertation, Michigan State University. See page 82.

Carnine, D., Engelmann, S., Hofmeister, A., & Kelly, B. (1987). Videodisc instruction in fractions. *Focus on Learning Problems in Mathematics, 9*(1), 31-52. See page 84.

Fullan, M.G., Miles, M.B., & Anderson, S.E. (1987). *Strategies for implementing microcomputers in schools: The Ontario case.* Ministry of Education, Toronto, Ontario. See page 60.

Kelly, B., Gersten, R., & Woodward, J. (1988). Research on teachers' implementation of an interactive videodisc curriculum. In T. Grady (Ed.), *Technology and curriculum* Alexandria, VA: ASCD. (in press). See page 84.

Mathinos, D.A., & Woodward, A. (1987) *The status of instructional computing in an elementary school: Removing those rose-colored glasses.* Paper presented at the annual general meeting of the American Educational Research Association, Washington, DC. See page 83.

Plomp, T., Steerneman, A., & Pelgrim, W.J. (1988, July). *Curricular changes as a consequence of computer use.* Paper presented at the European Conference on Computers in Education, Lausanne, Switzerland. See page 83.

Perhaps the major trend I see emerging in the research over the last four years is the growing recognition of the impact of a complex set of "implementation variables" on any subsequent impact of computer experiences on students. At the most fundamental level, implementation barriers can discourage or prevent the teacher from making use of computers at all. Many studies acknowledge the importance of an implementation perspective, but four (Beaver, Fullan et al., Mathinos & Woodward, and Plomp et al.) focus specifically on specifying implementation variables. The Fullan et al. study is the most comprehensive and useful. They synthesize a large number of studies and conclude that we have "vastly underestimated how difficult it is for teachers to implement the changes new technologies will require in practice."

Three studies suggest strategies to improve implementation. Van den Akker describes the development and testing of support materials with this aim. The Carnine et al. and Kelly et al. studies describe design decisions incorporated into interactive video materials that anticipate implementation support in the classroom. The importance of this sort of global thinking about computer use is becoming more and more clear.

OTHER TOPICS

I can divide the remainder of the Research Windows studies into four categories—studies relating to gender, research summary studies, cost-effectiveness, and a final miscellaneous category.

Gender and Computer Use

Although gender appears in many studies as a variable associated with computer use and impact, it is the specific focus of seven studies:

Collis, B., & Ollila, L. (1986). An examination of sex differences in secondary school students' attitudes toward writing and toward computers. *The Alberta Journal of Educational Research, 32*(4), 297-306. See page 51.

Horton, N.J. (1987). *Sex differences in attitudes toward computers.* Unpublished manuscript, Department of Psychology, Harvard-Radcliffe Colleges, Cambridge, Massachusetts. See page 60.

Peterson, P.L., & Fennema, E. (1985). Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics. *American Educational Research Journal, 23*(3), 309-335. See page 27.

Siann, G., Durndell, A., MacLeod, H., & Glissov, P. (1988). Stereotyping in relation to the gender gap in participation in computing. *Educational Research, 30*(2), 98-103. See page 81.

Smith, J. (1986). *Computer attitude survey of eighth grade students.* Unpublished Master's thesis, Seattle Pacific University, Seattle. See page 40.

Swadener, M., & Hannafin, M. (1987). Gender similarities and differences in sixth graders' attitudes toward computers: An exploratory study. *Educational Technology, 27*(1) 37-42. See page 51.

Ware, M.C., & Stuck, M.F. (1985). Sex-role message vis-a-vis microcomputer use: A look at the pictures. *Sex Roles*, 13(3/4), 205-214. See page 36.

Most of these studies document and attempt to interpret an unequal participation rate between males and females with respect to computer use. Attitude, self-confidence, and perception of what is appropriate gender-related activity continue to be major factors in the disproportionally small number of females who persist in computer usage. The most recent of these studies—Siann et al.—suggests some encouraging trends, but in general girls still make less use of computers than boys. Peterson and Fennema suggest a strategy in the context of mathematics education that could transfer to the computer use setting—implement more cooperative learning situations with computers and avoid software or instructional environments that stress interpersonal competition.

Research Summaries

Four citations related to studies that were themselves syntheses of other studies:

Govier, H. (1988). *Microcomputers in primary education: A survey of recent research.* Occasional Paper ITE/28a/88. Lancaster, UK: Economics and Social Research Council. See page 82.

Pike, R. (1985, April). *Looking at learning from lessonware.* Paper presented at the ECOO/AEDS Conference, Montreal, Quebec. (Contact Dr. Pike at Faculty of Education, University of Toronto, 271 Bloor Street West, Toronto, M5S 2R7). See page 25.

Roblyer, M.D. (1985). *Measuring the impact of computers in education: A nontechnical review of research for educators.* Washington, D.C.: AEDS (Association for Educational Data Systems). See page 23.

Samson, G.E., Niemiec, R., Weinstein, T., & Walberg, H.J. (1985). *Effects of computer-based instruction on secondary school achievement: A quantitative synthesis.* Paper presented at the annual meeting of the American Educational Research Association, Chicago. See page 36.

It is difficult here to summarize trends from large summary studies. However, we see some patterns. Using a computer to supplement regular, teacher-led instruction is generally more effective than trying to use a computer to provide the instruction. Students working in pairs rather than individually at computers are showing good results. The impact of [illegible] programs is strongest during the initial period of using the programs. And both the implementation of computers in education and research about computers in education are complicated and difficult processes.

Cost-Effectiveness Studies

Only two studies related to cost-effectiveness:

Hawley, D.E., Fletcher, J.D., & Piele, P.K. (1986). *Costs, effects, and utility of microcomputer-assisted instruction.* Eugene, OR: Center for Advanced Technology in Education, University of Oregon. See page 53.

Levin, H.M., (1986). *Cost-effectiveness of computer-assisted instruction: Some insights.* Stanford Education Policy Institute, Report 86-SEPT-13, Stanford, CA 94305. See page 48.

However, I mention them especially because I predict this is an area where much more work is going to appear. It is inevitable that we will have to become more accountable about the time and money we are spending on computer activities in schools. The attention given to the need for this approach in the *Power On* report from the US Office of Technology Assessment is an indication of this. The two studies that were reviewed in Research Windows are important baseline documents in this area. Each presents a careful methodology for calculating the cost-per-student of computer use (in mathematics drill) with the cost of traditional instruction. Levin found wide variations in cost-per-student amounts relative to computer use, even when the components of this use were supposed to be comparable in different schools. Hawley et al., found that the cost-per-student per-day in computer-supported mathematics programs was considerably greater than that in traditional programs. However, the students working with the computers did significantly better that the "traditional" students; Hawley and his colleagues developed a weighting technique to help decision makers consider valu• of results as well as costs.

Miscellaneous Studies

The remaining studies cover a variety of topics. I mention them for those who are interested in pursuing a particular issue:

- **Readability inconsistencies in software**

  Dunsmore, G.A. (1985). Readability assessments of elementary level microcomputer courseware. *AEDS Journal, 18*(4), 267-276. See page 25.

- **Parents' expectations for children's computer literacy**

  Clayborne, B.M. (1985). *Dimensions and correlates of the attitudes of inner city parents toward microcomputers in education.* Unpublished manuscript, University of Maryland. See page 27.

- **Secondary students' home use of computers**

  Carey, R.F. (1985). *Patterns of microcomputer use by secondary school students at home and school.* Unpublished doctoral dissertation, University of Oregon, Eugene, OR. See page 30.

- **Computer games and their effect on spatial ability**

  McClurg, P.A. (1985). *A study of the effects of playing selected microcomputer games on the spatial ability of fifth, seventh, and ninth grade males and females.* Unpublished doctoral dissertation, University of Oregon. See page 33.

- **Computer games and their effect on aggressive behavior**

  Silvern, S.B. (1986). Video games: Affect, arousal, and aggression. In P. Campbell & G. Fein (Eds.). *Young Children and Microcomputers*, pp. 62-70. Englewood Cliffs, NJ: Prentice-Hall. See page 47.

- **Computer related vocational needs and the implications for school computer literacy curricula**

  Levin, H.M., & Rumberger, R.W. (1986). *Education and training needs for using computers in small businesses.* Report 86-SEPT-7. Stanford, CA: Stanford Educational Policy Institute. See page 46.

- **The "Hidden Curriculum" of computer use**

  Roessler, M.J. (1987). *Fourth graders and computers: A case study.* Unpublished doctoral dissertation, Michigan State University, Lansing, Michigan. See page 59.

- **Comparison of working in pairs and working individually at the computer**

  Carrier, C.A., & Sales, G.C. (1987). Pair versus individual work on the acquisition of concepts in a computer-based instructional lesson. *Journal of Computer Based Instruction, 14*(1), 11-17. See page 61.

- **Computer competencies valuable for preprofessional training**

  Kurshan, B. (1986, May). *Career paths of women graduating with technological courses.* Paper presented at the World Congress of Education and Technology, Vancouver, B.C. See page 67.

- **Natural curiosity and software exploration**

  Lancy, D.F. (1988, April). *Individual variation in working/playing with computers.* Paper presented at the annual meeting of the International Association of Computing in Education, New Orleans. See page 78.

- **Strategies for interactive video**

  Mably, C. (1987). Interactive video as a school resource: Rolls Royce or Model T Ford? In D. Laurillard (Ed.), *Interactive media: Working methods and practical applications*, pp. 1901-204. Chichester, West Sussex, UK: Horwood Limited. See page 84.

SUMMARY

In conclusion, after reviewing these 180 studies and reflecting on others that I have read but didn't review, I offer these final generalizations about overall trends emerging from the studies, either explicitly or implicitly:

- There are no easy answers or simple conclusions about the impact of computer use in education.

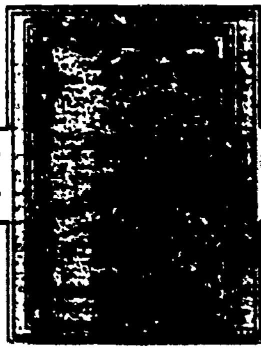
- Teachers are critically important in whatever happens whenever computers are used (or not used) in education.

- Classroom implementation of computer use is typically a challenging task.

- Computers have been and continue to be remarkable catalysts for educational excitement, self-examination and growth

It is this last point perhaps that is most important of all.

Research Windows, Volume 13
1985-1986

RESEARCH  WINDOWS

Edited by Betty Collis

"Research Windows" is a new feature of TCT. Each month this column will present short summaries of various research studies relating to computers in education. To be included, a study must reflect well-designed research procedures and suggest practical applications for the educator concerned about teaching with computers. The column will include research studies from a variety of sources including journal articles, papers presented at conferences and unpublished research reports. We ask for your help in locating good research studies that will be of interest to readers of TCT. Please send journal references or copies of papers and reports to: Betty Collis, Research Windows Editor, Dept. of Psychological Foundations, Faculty of Education, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2.

Computer Literacy by Osmosis?

Battista, M.T., & Steele, K.J. (1984). The effect of computer-assisted and computer programming instruction on the computer literacy of high ability fifth grade students. *School Science and Mathematics, 84*(8), 649-658.

Sometimes it is felt that a reasonable level of computer literacy will occur, almost by osmosis, if students regularly use a computer and especially if they are programming. In this study one group of elementary students used a computer for mathematics drill and another group undertook a series of lessons in BASIC. "Neither treatment was effective in developing an adequate level of cognitive computer literacy," although students in both groups demonstrated a more positive attitude about computers than students in a control group. The study concludes that knowledge about how computers work, what kind of tasks they perform, and how they are used in society probably will not develop incidentally during various classroom computer activities but must be pursued like other learning objectives.

Logo and Thinking

Clements, D.H., & Gullo, D.F. (1984). Effects of computer programming on young children's cognition. *Journal of Educational Psychology, 76*(6), 1050-1058.

Ever since Papert first presented his hypotheses about Logo and children's thinking, many of us have been waiting for research results about the effects of Logo experiences on young children's activities and development. In this study 18 six-year-old children were randomly assigned to 12 weeks of CAI experiences in reading and mathematics or to a similar amount of time with Logo. The CAI children showed no change in any of the cognitive variables being measured, but the Logo children showed an increase in "fluency and divergent thinking," in the amount of time spent considering a problem before answering, and in their ability to indicate that they did not understand instructions. Neither group of children, however, showed changes in cognitive development as measured on two Piagetian tasks. Because of the small number of subjects and short time involved, this seems yet another study which lacks the empirical data needed to really examine the impact of Logo on cognitive development.

Ways to Learn Word Processing

Wagner, W.G., O'Toole, W.M., Kazelskis, R. (1985). Learning word processing skills with limited instruction: An exploratory study with college students. *Educational Technology, XXV*(2), 26-28.

Although this study involved college students, the results seem generalizable to secondary school students and could be quite useful. Students were divided into three groups prior to their initial use of a word processor. One group was simply given a manual, another group was given the same manual but had an instructor go through the manual with them in a typical lecture-question manner, and the third group was given the manual and the instructor and in addition the instructor demonstrated various points on a microcomputer. Each group had one hour of instruction and then was given one hour to use the word processor. The group who had had a computer demonstration wrote much more than did students in the other group and also indicated a more positive opinion about the experience. It was especially interesting that traditional lecture methods were no more effective than simply giving students a good manual with respect to learning word processing, but the major emphasis of the study was "the importance of actually showing students what they are to do on a microcomputer."

Language and Programming Skills

Kagan, D.M., & Douthat, J.M. (1984). Writing style, category width, and introductory FORTRAN. *Journal of Research and Development in Education, 18*(1), 7-11.

Does programming skill have a strong relationship with verbal and communication ability? Kagan and Douthat gathered data about this question from 143 university students enrolled in an introductory programming course. Language skills seemed strongly related to females' final performance in the course but not males'. In addition, females' early performance in the course was a strong predictor of their final performance, but this prediction was not particularly strong for males. The ability to edit effectively and rewrite a paragraph was strongly associated with success in programming.

Software Evaluation

Preece, J., & Jones, A. (1985). Training teachers to select educational computer software. *British Journal of Educational Technology, 16*(1), 9-20.

Eighteen computer-using teachers were asked to evaluate three educational software packages. Detailed checklists were supplied and the teachers were given training in developing criteria for selecting and evaluating educational software. Despite this, the teachers were "not very critical" in their evaluations, frequently gave a higher summary rating than their ratings for individual features would suggest, and made few suggestions for improvement. The researchers concluded that "discriminating between good and bad features of software is not a trivial task" and is unlikely to occur by leaving teachers to work through packages even after training. Teachers were strongly influenced by the graphics in a program, but were less likely to consider the underlying educational structure or objectives.

[Dr. Betty Collis, Faculty of Education, University of Victoria, Victoria, B.C., Canada, V8W 2Y2.]

RESEARCH WINDOWS

Edited by Betty Collis

The first three studies in this month's "Research Windows" were presented at the Annual Meeting of the Association for Research in Science Teaching, French Lick Springs, Indiana.

Computer Literacy Competencies for Science Teachers

Ellis, J.D., & P.J. Kuerbis (1985, April). *Development and Validation of Essential Computer Literacy Competencies for Science Teachers.*

Science teachers, principals and educational computing specialists were surveyed to determine what they felt to be the most important computer literacy competencies for science teachers. Out of 160 competencies, the respondents ranked most highly:

- Use the computer as a tool in the classroom;
- Integrate the use of computers with non-computer materials, such as textbooks;
- Describe appropriate uses for computers in teaching science; and
- Respond appropriately to common error messages when using software.

The respondents expressed relatively little interest in competencies related to computer programming, the history of computing, and computers and society.

These results are important for those who plan teacher inservice; I would like to see other teacher populations similarly surveyed.

Testing With and Without Computer Animation

Hale, E. H., & J. R. Okey (1985, April). *Using Computer Graphics and Animation in Testing.*

Will questions referring to dynamic action events in science be easier for students to understand if they can see an animated visualization of the problem situation on a computer as they answer? Will poor readers and poor visualizers be particularly helped? In this study, 94 middle school students took a 26-item "science process skill test." Half the children had the written questions only; the other half had the same questions delivered via a computer where computer graphics and animation were used to dynamically portray the phenomena that were at issue in the test questions. Rather surprisingly, there was no difference in the scores of the children in the two groups. The researchers suggest reasons which may have contributed to the relative lack of impact of the computer:

- Students had to focus so much on the computer that they did not pay adequate attention to the test material;
- The visualizations were of things like basketballs bouncing, planes flying and plants being watered, and students may have already had good mental images of these—in other words, the pictures did not supply anything new;
- Some of the computer screen displays were unclear and confusing; and
- It took three times as long to take the computer-delivered test because of disk access and animation.

These criticisms are pertinent to educational software in general, and make this study particularly useful.

Scientific Process Skills: Programs Vs. Lab Work

Shaw, E. L., Jr., & J. R. Okey (1985, April). *Effects of Microcomputer Simulations on Achievement and Attitudes of Middle School Students.*

Do programs such as *Moptown Parade, Moptown Hotel, Gertrude's Secrets* and *Gertrude's Puzzles* provide as effective or even more effective training in scientific process skills compared to traditional classroom methods? Various classes of sixth and seventh graders used these four programs as their major science class activity for two weeks. Other groups experienced laboratory activities of various kinds. The science process skills of interest were observing, classifying, ordering, hypothesizing and testing. The computer groups did no better on a subsequent process-classification test than did students in other groups where these skills were the focus of manipulative activities, nor were they more positive about computer use. While certainly more effective than no instruction, the use of the computer programs did not seem to contribute any more to the instructional setting than could be achieved using traditional activities. In addition, this study found no interaction between the child's level of reasoning ability and type of learning experience.

The next two studies are also of interest to all computer-using educators.

Discovery Learning and Locus of Control

Louie, S. (1985). *Locus of Control Among Computer-Using School Children.* (Available from NACCIS, 2200 East River Road, Suite 125, Tucson, AZ 85718, $11.50).

"Locus of control" is a way of expressing the degree to which individuals feel they can control what happens to them. Persons with internalized locus of control tend to believe what happens to them is a result of their own behaviors or characteristics, while persons with externalized locus of control tend to believe things happen because of luck, fate or powerful others. Internalized locus of control has been associated with grade point average, reading and math achievement and success with discovery or inductive learning, and seems to be consistent with Papert's vision of the development of a sense of "empowerment" through Logo activities. The study examined the impact of open-ended computer use via Logo experiences and word processing on students' level of internalized locus of control. Forty-six students ages nine through 15 (13 females) who attended a voluntary summer computer camp were tested at the start and finish of a 16-hour (four-week) camp experience. Although the shift was slight, the group did demonstrate a higher level of internal locus of control after the Logo word processing experience. The differences were most clearly seen in the students' sense of how much they could control the reactions of others to them (as measured by items such as "Do you feel that when someone doesn't like you there's little you can do about it?") and in their sense of control over "outer-world" events. However, the students also showed a slight shift toward more dependence on authority figures after the computer experience. This connection between Logo and word processing (developed in a group situation, as was the case in this study) and locus of control may provide another important reason for promoting these types of computer experiences in schools.

Programming Ability: Impacts and Outcomes

Linn, M. C. (1985). The Cognitive Consequences of Programming Instruction in Classrooms. *Educational Researcher, 14*(5), pp. 14-29.

In a series of studies, Linn and her colleagues examined the effects of programming instruction and the relation between student characteristics and outcomes for such instruction. They studied middle school students in four "typical" schools and found that after 12 weeks of instruction in BASIC students had learned some of its language features but apparently did not move beyond this knowledge level into skill development which might be associated with gains in problem solving ability. They found a direct relationship between general ability and programming achievement, between time spent at a computer and programming achievement, and between home access to a computer and programming achievement. All this seems predictable, although the lack of development of higher-level thinking associated with problem solving is disappointing. What is interesting is that students from two "exemplary" schools were also studied. These schools featured more experienced teachers who explicitly taught the students how to design programs as well as learn a programming language. (The students, however, were also "somewhat higher" in general ability.) In these exemplary schools, students were able to demonstrate higher-level thinking associated with problem solving and many were able to design and write programs in a language new to them during a test situation. Also, middle-ability students were able to do as well in programming achievement as high-ability students and home access to computers was no longer an advantage for programming achievement. This result suggests that teaching approach can make a significant impact.

[Research Windows presents short summaries of research studies relating to computers in education. We welcome your help in locating appropriate research. To send copies of papers or reports or for further information about the studies in the column, write Betty Collis, Editor, "Research Windows," Dept. of Psychological Foundations, Faculty of Education, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2.]

RESEARCH WINDOWS

Betty Collis

Special Students Could Use More Computer Time

Thormann, J., & Gersten, R. (1985). *Microcomputer Use in Special Education: An Empirical Investigation of Teachers' Perception*. Manuscript submitted for publication.

All special education coordinators in Oregon were surveyed regarding the current use of microcomputers with special education students in public school districts in the state. Only 31 percent of the coordinators indicated that special education students in their districts use computers. Those who *do* use them mainly for drill and practice in mathematics and language arts. Special ed teachers "rarely" use computers to teach new concepts or to use "innovative features" such as simulations or programming. The survey concludes that computers primarily serve a "workbook function" for special education students in Oregon, and even this workbook experience amounts to only about six minutes per student per day. However, despite this minimal usage, both qualitatively and quantitatively, special ed teachers feel that the computer is a "good motivator" and boosts self-esteem for their students.

I find these data frustrating; how can we expect any lasting impact on motivation and self-esteem when such limited interaction with computers actually occurs?

Some General Truths

Roblyer, M. D. (1985). *Measuring the Impact of Computers in Education: A Non-Technical Review of Research for Educators*. Washington, DC: AEDS (Association for Educational Data Systems).

This excellent summary of research activity in the area of the impact of computers on instruction shows that a few results have been replicated enough times that teachers can feel some confidence in generalizing from them. The three findings that seem most useful to teachers are:

- The impact of computers is highest with young children and decreases steadily as grade level increases;
- Using a computer to supplement regular teacher-led classroom instruction is more effective than trying to use a computer to provide the instruction; and
- In mathematics, younger and lower-ability students learn better from drill and tutorial programs while other students "appear to profit more from tutorial-type CAI."

It is interesting to compare the first finding above with the fact that secondary schools still have many more computers than elementary schools.

CAI Increases Academic Self-Confidence

Griswold, P. A. (1984). Elementary Students' Attitudes During Two Years of Computer Assisted Instruction. *American Educational Research Journal, 21*(4), 737-754.

The attitudes of fourth and fifth graders who did or did not participate in drill-based CAI in mathematics and reading were studied over a two-year period. The children involved in the CAI experience did not differ from the non-CAI children in attitudes toward school or toward mathematics after two years of participation. However, children in the CAI experience did develop a stronger sense of academic self-confidence and a greater sense of personal responsibility for success than did the non-CAI children. This finding was especially strong for educationally disadvantaged children.

This study fits in well with the two above—it provides empirical support for special education teachers' impressions that computer-learning experiences provide some kind of positive affective results for their students, and it also reflects the finding that drill-type mathematics CAI is effective with lower-ability students.

Computers Are Great But I....

Norris, C. M., & Lumsden, B. (1984). *Functional Distance and the Attitudes of Educators Toward Computers. T.H.E. Journal*, pp. 129-132.

One more study about attitudes—this one to do with the opinions of 450 teachers in Denton, Texas about computers in education. Eighty-five percent of the respondents agreed that "computers are valuable tools that can be used to improve the quality of education" and 81 percent indicated they believe that "teachers should know how to use computers in their classrooms." Despite these stated convictions, however, only 66 percent indicated they would actually like to have one in their own classrooms.

These data make me wonder if computer use is becoming an "in" thing, like jogging or exercise, which we feel we should endorse even if we find it hard to actually get around to doing it. Will it be a good thing if computer use in the classroom becomes something like dieting—we all know we should be doing it, we feel vaguely guilty if we're not, and we tell each other that we're making plans to really plunge into it, starting next week—?

Research Windows. . .

A Better Angle on Software

Bailey, B. (1984). 'Tanker': A Small Piece of Evaluation. *Micro-scope, 11,* 13-14.

This is a short report in a British primary teachers' journal in which a classroom teacher discusses the results obtained by his 20 nine-year-old children on a test in estimation of angle measure before and after they interacted with a computer simulation program. In the program the children had to refine their estimates of angle measure in order to manuever a submarine. (This program seems very similar to some typical Logo activities.) After only 20 minutes apiece at the computer, all but two of the children improved their scores on angle estimation.

I like this little report and wish I could see more like it in teachers' journals. Unlike many software evaluations, which often fail to include any specific student achievement data, it shows the type of information each computer-using teacher could collect and share so that we can more easily identify simple programs which work in the classroom.

RESEARCH WINDOWS

Betty Collis

This month we look at three studies investigating the effects of various features of educational software, one describing the impact of incorporating programming as part of grade 11 mathematics, and one identifying some very useful insights about the impact of word processing on writing performance.

Text on the Computer

Heppner, F. H., Anderson, J. G. T., Farstrup, A. E. & Weiderman, N. H. (1985). Reading performance on a standardized test is better from print than from computer display. *Journal of Reading, 28*(4), 321-325.

Eighty-five adult subjects drawn from the students, staff and faculty of the University of Rhode Island took part in a well-designed experiment that compared the reading of text from a computer screen with that from ordinary print. Identical questions from a standardized reading test appeared in the two presentations and each student took Form A of the test in one mode and parallel Form B in the other mode. Students had significantly lower scores on whichever form they took on the computer, a pattern established for regular computer users as well as nonusers (but not for "heavy TV viewers"). The difference in performance scores was "probably due to a reduction in reading speed associated with using a terminal." The subjects also expressed "strong subjective beliefs that they could read print material faster and that it was easier to comprehend." These results are important for both teachers who use programs involving reading and those who design them.

Readability Levels of Software

Dunsmore, G. A. (1985). Readability assessments of elementary level microcomputer courseware. *AEDS Journal, 18*(4), 267-276.

The readability level of courseware is an important issue. Publishers frequently label their software as appropriate for a range of grade or reading levels. This study investigated these claims by applying various readability formulas and programs to commercial educational software and comparing the results to the publishers' statements for five of these packages. It was found that the publishers' recommended grade ranges should be "used with caution," especially for the lower end of the ranges. One of the packages, for example, was advertised as appropriate for ages 9-11 but was assessed using the Dale-Chall Formula as appropriate for 7th and 8th grades (ages 11-14). These data are important, and frustrating, for teachers purchasing software packages. Let the buyer beware.

Field Studies of Software Use

Pike, R. (1985). *Looking at learning from lessonware.* Paper presented at the ECOO/AEDS Conference, Montreal, Quebec. (Contact Dr. Pike at Faculty of Education, University of Toronto, 271 Bloor Street West, Toronto, Ontario, M5S 2R7.)

The Exemplary Lessonware Project of the Ministry of Education of Ontario involves the development and field testing of educational software. This report summarizes evaluation studies based on classroom use of over 40 of these programs. Highlights of the summary include: Successful software was unrelated to curriculum area; review programs were more effective than those which attempted to teach new content; students were "not reliable reporters" about the presence or absence of various educational features of the programs; and having appropriate prerequisite content skills was more important to learning outcomes than prior computer experience. Also, "girls are more cautious and hesitant to use the computer and required more instruction on didactic, problem and simulation programs than boys" and elementary boys enjoy simulations more than elementary girls. As the author summarizes field tests involving the Ontario lessonware, she notes that "the results are indeed modest. Neither the positive nor negative rhetoric (about computer applications) has been supported.

Programming As a Way to Learn Mathematics

Sigurdson, S. E., & Hunka, D. (1985). *Integrating programming into mathematics.* Planning Services, Alberta Education, Devonian Building, West Tower, 11160 Jasper Avenue, Edmonton, Alberta, T5K 0L2.

This report describes and evaluates a 15-hour elective unit in grade 11 mathematics which taught students to program, in BASIC, solutions to typical grade 11 mathematics exercises. After the unit, students in the five "Computer Programming in Mathematics" (CPM) classes were compared with other grade 11 students. Those in the CPM classes were not significantly different from those in the non-CPM classes in mathematics understanding after the CPM unit although they were more "aware of computers" and knew more BASIC. Interestingly, while the attitudes of the CPM and non-CPM students were not different in terms of overall "liking" of computers or in perceived difficulty of computer use, the students who had used the computers as part of mathematics class for 15 weeks were significantly more negative about the usefulness of computers than the non-CPM students. Despite these somewhat discouraging results, the CFM lesson materials, which are included in the report, seem very useful and well designed. I especially like the practice of having the students write simple programs which they then use for subsequent textbook exercises. I recommend the report to all those involved in secondary mathematics teaching for the quality and detail of its planning, and to all involved in classroom computer-use projects for the model this carefully done evaluation ..port provides.

Application of Word Processing Skills to Writing

Wolf, D. P. (1985). Flexible texts: Computer editing in the study of writing. In E. L. Klein (Ed.), *Children and computers* (pp. 37-53), New Directions for Child Development, no. 28. San Francisco: Jossey-Bass.

Four children aged 11 and 12 and four adolescents between 13 and 15 were studied as they used word processors over a two-month period. Although all of the students could perform local editing tasks, the younger writers did not seem to consider the chain of problems that a local revision could cause throughout a text. Also, when the students were asked to expand their stories, the younger writers inserted new entries only at the beginning or end of the stories or at paragraph boundaries, whereas the older writers "thickened or embroidered" text throughout their stories. The younger students tended to use word processing tools for line-by-line proofreading whereas the older students "widened their window of writing that they can consider as connected text." This is a valuable observation; the sheer existence of the capacity to perform global editing is of little use to students unless they are first taught "to think in terms of large-scale changes and to make such changes with an eye on the resulting ripples of effects throughout their texts."

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RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we look at a practical study about new language arts content based on the vocabulary necessary for following instruction in computer software; a study which could challenge our thinking about immediate and attractive rewards for correct answers in computer software; and a study which reinforces the importance of parental attitude and experience to student achievement with computers. Finally, two studies describe differences in how males and females benefit from various instructional approaches, including Logo, games and cooperative learning.

Assessing the Value of Immediate Feedback for Correct Answers

Beaulieu, J.E. (1985). *A study of the effects of selected feedback delay intervals upon retention of science material in a computer assisted instructional task with junior high school students.* Unpublished doctoral dissertation, University of Oregon.

The ability to provide immediate feedback to student responses is often felt to be one of the strengths of computer delivered learning experiences. Beaulieu studied this assumption by varying the time delays between 0 and 10 seconds before feedback appeared to student answers. He found that the choice of immediate or delayed feedback didn't seem to make any difference on how well students learned or retained the material either immediately, after 24 hours, or after seven days. He also found that students paid relatively little attention to feedback to correct answers, especially when they were confident of their answers based on previous successful performance. However, students spent "twice as much time studying the feedback when their responses were incorrect." We should consider these data when we consider software which generates a variety of elaborate rewards to correct answers—do the students really care? And what can we do to capitalize on their heightened attention when an "incorrect" message is given? Perhaps here is where important teachable moments occur; software developers should examine this carefully.

Parents' Expectations for Their Children's Computer Achievement

Clayborne, B.M. (1985). "Dimensions and correlates of the attitudes of inner city parents toward microcomputers in education." Unpublished manuscript, University of Maryland.

One hundred and four parents (23 fathers and 81 mothers) of junior high school students in Washington, DC, responded to a survey which compared their opinions about the importance of microcomputer knowledge to future employability for boys and for girls. With so many studies suggesting parents have lower expectations for their daughters than for their sons, it is heartening to note that in this study no significant differences were found between either mothers' or fathers' attitudes toward the value of computers for either their sons or daughters. Also, this study found that the more experience parents themselves have with computers, the more likely they are to value computer education for their children. These results suggest a different approach to computer literacy: Perhaps school districts could develop computer access and instruction for parents as well as students in a deliberate strategy to improve students' attitudes toward computer use.

Logo and Adolescent Females' Mathematics Achievement

Howe, J. (1985, March). Logo programming and intermediate mathematics. *Computers in Education*, pp. 7-10.

Approximately 160 Scottish students, ages 12 to 13, were divided into two groups, one of which used Logo throughout a school year, applying it to the context of various topics within the regular mathematics curriculum. The Logo students spent up to 40 hours each at computers during the year. There was no significant difference in mathematics achievement between the Logo and non-Logo students either at the start or, despite all the Logo, at the end of the school year. However, interesting sex differences were masked by this overall similarity. The end-of-year performances of males and females in the Logo group were not significantly different; however, in contrast, males in the control class did end up doing significantly better than females in the control class. Also the achievement gap between the female Logo group and the female control group "widened appreciably during the year," but there was no difference between the achievement of boys in the Logo and non-Logo groups. This finding seems to have great potential; perhaps Logo's value is especially high with adolescent females. However, one last result tempers our optimism: There was no evidence in improvement in the Logo females' attitudes toward mathematics over the year, and in fact, Logo females displayed a drop in motivation during the year.

Competition vs. Cooperation for Males and Females

Peterson, P.L. & Fennema, E. (1985). Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics. *American Educational Research Journal, 22*(3), pp. 309-335.

This study, unlike any other which has appeared in "Research Windows," did not involve computers. However, its findings relate clearly to an important issue in computer applications in education: Are different teaching methodologies more effective for some groups of students than for others? In this study, 36 fourth grade teachers and their classes were examined in regard to what actually occurs during mathematics lessons. Sex differences were found; in particular that girls did better in mathematics when they had the opportunity to engage in mathematics activities that were cooperative, rather than competitive. In fact, for girls, class use of competitive mathematics activities was negatively related to achievement on knowledge and application-level math. For males, the correlation between engagement in competitive mathematics activities and "low-level" (LL) math achievement was "slightly positive." Also, "classes in which boys gained more than girls in LL achievement items spent significantly more time in competitive mathematics activities than did classes where there was no difference in girls' and boys' LL achievement." However, for girls, involvement in cooperative mathematics was significantly related to both LL and high-level (HL) mathematics achievement. For boys, cooperative learning activities were "significantly negatively related to HL mathematics achievement." These findings reflect directly on the choice of games as computer-based methodology in our classes and give us specific data to support our consideration of different computer-based activities for young boys and girls, at least in mathematics.

New Sight Words for Computer-Using Children

Dreyer, L.G., Futtersak, K.R. & A.E. Boehm (1985). Sight words for the computer age: An essential word list. *The Reading Teacher, 39*(1), pp. 12-15.

Young children who use computer software are frequently expected to understand various "new" words, such as MENU, CONTINUE, SPACEBAR and KEYBOARD, which are not included in traditional sight reading lists or classroom readers. In this study, Dreyer and her colleagues examined 35 commercial software packages which they considered to be in relatively widespread use in elementary schools. They tallied the words which appeared as part of the on-screen instructions to the students and compared these words to standard sight-word lists. Many words that appear as part of the instructions of programs for young children are not typically included in the sight-word lists which these children are using in their language arts classes. These words include: ADJUST, CATALOG, CHANGE, COMMAND, COMPUTER, CONTINUE, CURSOR, DELETE, DIRECTIONS, DISPLAY, EXIT, INSERT, KEY, KEYBOARD, SPACEBAR and TYPE.

The authors conclude that language arts teachers need to be sensitive to the need to teach new vocabulary, both as sight words and in context, even though the printed texts and standard word lists do not yet reflect it.

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RESEARCH WINDOWS

Betty Collis

In this month's *Research Windows* we examine one study which supports the value of computer experience in elementary mathematics, three which supply findings relative to the design of effective educational software, and one which describes what secondary school students do at home with computers.

CAI and Elementary Mathematics

Mevarech, Z.R., & Rich, Y. (1985). Effects of computer-assisted mathematics instruction on disadvantaged pupils' cognitive and affective development. *Journal of Educational Research, 79*(1), 5-11.

There are encouraging data in this study from Israel involving third, fourth and fifth graders from six schools categorized as disadvantaged. In three of the schools, one of the four mathematics periods per week involved use of CAI drill practice, while in the other three schools the same amount of time was used for regular classroom mathematics work. The computers in the CAI schools had been in use for at least three years, so the motivation accompanying a new innovation was not judged to influence the results. At all three grade levels, pupils in the CAI classes reported more positive perceptions of school life and higher mathematical self-concepts and attained higher scores on mathematics achievement tests than did the children in the non-CAI schools. There were no sex differences in these attitude and achievement data. Although the researchers did not have pretreatment data on the children to determine whether differences were already existing before the CAI treatments began, the results firmly support that CAI in mathematics "holds promise for the simultaneous enhancement of disadvantaged pupils' cognitive and affective development."

Display Time and Example Selection

Tennyson, R.C., Park O.C. & Christenson, D.L. (1985). Adaptive control of learning time and content sequence in concept learning using computer-based instruction. *Journal of Educational Psychology, 77*(4), 481-491.

It is often felt that the ability of certain CAI programs to "patiently wait" for a learner to respond and to ask additional questions if an incorrect response is given can make valuable contributions to learning. In this study, Tennyson and his colleagues found that a computer-controlled display time (adapted continuously on the basis of calculations specific to the individual student) resulted in quicker and more effective learning than did student-controlled display times. Also, when students continued to make incorrect responses, it was found that first presenting examples illustrating the current concept and then giving examples from previous concepts was more effective than other example-selection strategies. The researchers feel that the timed displays help slow learners maximize their ratios of on-task/off-task learning time and this develops concentration strategies more like those of faster learners. This clearly can be an advantage that computer-delivered practice can supply, but tests and printed sheets cannot.

Questioning Techniques

Tamborine, R. (1985). Effects of questions, personalized communication style, and pauses for reflection in children's educational programs. *Journal of Educational Research, 79*(1), 19-26.

Although this research focuses on television programs, not computer programs, its findings seem to relate directly to the design of educational software. Fifty-two kindergarten and first grade children were shown various versions of a television program. In some versions, the commentator interspersed the story that was being read with "personalized-rhetorical questions" ("What do *you* think will happen next?"); in others the questions were only rhetorical ("What happened next?"); and in others, no questions were inserted. Children retained more information when personalized questions were included than they did following the impersonal-question or no-question versions. However, a second variable, use of pauses after questions or statements, produced interesting information. When pauses were inserted after personalized questions or after statements, the young children became inattentive, as measured by eyes-off-screen time. Perhaps this also suggests that computer software for young children should not be paced to move as slowly as it often does now. Also, the insertion of personalized questions whenever appropriate may be more effective than the short, somewhat cryptic inquiries (AGAIN? or NEXT?) often used in software for young children.

Visualizing Algebra

Reed, S. K. (1985). Effect of computer graphics on improving estimates to algebra word problems. *Journal of Educational Psychology, 77*(3), 285-298.

Three well-known types of algebra word problems are those involving average speed, tanks filling at different rates, and mixtures of concentrations. Reed investigated the impact of various programs with graphic representations on the ability of university undergraduate students to estimate reasonable answers to these types of word problems. He found that the quality and quantity of feedback provided to students seemed to be the most important component associated with improvements in comprehension. Expecting students to infer principles from graphic representations, even dynamic computer simulations, is not enough to improve learning, as students lack the ability to perceive the relevant inferences from what they are shown. Graphic displays in general did not have the impact that was expected; students given precise answers to various example problems delivered in text form did as well as students who were shown visualizations and then given precise answers to example problems.

I am not sure whether the results of Reed's many experiments (each involving different combinations of variables) tell us much we didn't already know; among his major conclusions are that students do better when test questions appear in the same format as example problems, and that students learn better when they have to respond and are given feedback than they do when they are only required to watch, even if the watching is directed at a computer monitor.

Home Use of Computers

Carey, R. F. (1985). *Patterns of microcomputer use by secondary school students at home and school.* Unpublished doctoral dissertation, University of Oregon, Eugene, OR.

While this month's other studies describe results of controlled investigations, Carey's research involved a survey of approximately 1,000 secondary school students concerning what uses they made of home and school computers. Approximately a third of these students had access to home computer systems. Younger students used them more than senior students, and entertainment, BASIC programming and word processing were the major home activities. As noted in so many other studies, males were the dominant computer users, both at school and at home. Only about 13 percent of the students used a computer both at home and at school, indicating that the home use reported in this study is probably largely voluntary and not being done in response to school assignments. Since this observation supports the ability and inclination of secondary school students to use computers independently, it suggests that free and unscheduled access to computers and applications software in secondary schools could be both practical and desirable.

RESEARCH WINDOWS

Betty Collis

This month's Research Windows examines four language arts-related studies and one involving mathematics CAI. Two of the studies explore the types of decisions students make when given control over the sequence of activities within a CAI experience.

Functional Communication

Riel, M. (1984). The Computer Chronicle Newswire: A functional learning environment for acquiring literacy skills. *Journal of Educational Computing Research, 1* (3), pp. 317-337.

Third and fourth graders with learning difficulties were involved in the development of a "newspaper" made up of articles written by the children in various schools and sent among the schools on computer disks. When they began their experiences, students used an "interactive writing system" which helped them decide what to write, but later wrote without prompting. After three months of newspaper involvement, their performance on a task involving writing a composition improved in a variety of ways in both quantity of writing and number of words used to describe activities, but more importantly in their appraoch to writing.

After experiencing some computer prompting and contributing for three months to the newspaper disks, the students "picked up their pens" and "began writing" without complaining or needing teacher suggestions as to their approach to writing.

Riel makes the interesting observation that when the students first began the experience, they entered a 98-word "joke section" for the newspaper in the same amount of time that they composed 24-word stories, "important because it demonstrates that the limited length of these early stories was *not* due to a lack of computer or typing skills" but that "the students simply did not know what to write." She also notes the importance of students working cooperatively on writing and experiencing writing as a form of functional communication. Even without the "interactive writing system," this experience of sending a "newspaper disk" to each member of a group of participating schools seems an excellent idea for teachers to consider.

Recopying Errors

Levin, J. A., Riel, M., Rowe, R. D. & Boruta, M. J. (1984). Muktuk meets Jacuzzi: Computer networks and elementary school writers. In S. W. Freedman (Ed.), *The acquisition of written language: Revision and response*. Hillsdale, NJ: Ablex.

Rowe compared data from 10 sixth grade students who had completed four writing tasks. These involved writing two stories, one by hand and one on a word processor, and then rewriting the stories for a final copy. He found that the children wrote more with pencil (average length 101.9 words) than they did on the word processor (58.8 words). There were 14.2 errors in the first paper and pencil drafts (0.14 errors/word) and 7.3 errors in the first word processed drafts (0.12 errors/word). In the rewritten versions, the students corrected 43 percent (6.2) of the paper draft errors and 78 percent (5.7) of the computer draft errors. Most importantly, however, the students made an average of 5.5 *new* errors when recopying on paper with pencils, but using the computer, only an average of 0.4 new errors were introduced. Thus the final drafts using pencil still contained a large number of errors (0.10 errors/word) whereas the word-processed second drafts were virtually error free (0.03 errors/word). This study concludes that rewriting pencil and paper drafts for elementary school students may even have a negative value in terms of improving a piece of text, "since new errors are introduced at about the same rate as old errors are corrected." Here is another valuable point to use in encouraging word processing for young writers.

Word Decoding

Chrosniak, P. N. & McCormick, G. (1985, April). *Computer aided reading with reading discouraged children*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago.

This study describes a computer system which allows the users to touch any word on the monitor with a light pen and immediately hear the word pronounced through a computer-controlled audio recording. The system was used with various groups of "reading discouraged" children who varied greatly in how many words they "touched" (between 1 percent and 74 percent of the words). Reading rate steadily improved for these children as they used the system over a four-month period and the children read "considerably more" (an average of 540 words per day) than their teachers estimated they would have in their regular reading classes. The system was seen as especially effective for children who would typically skip over unfamiliar words or would spend inordinate amounts of time on such words. With this approach, poor readers are given a useful tool for coping with reading problems. This research might be quite valuable to learning assistance language specialists and is fully described in the report available from the authors at the Center for the Study of Reading, University of Illinois at Urbana-Champaign.

Learner Control of Help Options

Reinking, D. & Schreiner, R. (1985). The effects of computer-mediated text on measures of reading comprehension and reading behavior. *Reading Research Quarterly, 20*(5), pp. 536-552.

This well-designed study investigated the effect of computer intervention on reading comprehension and also examined the types of interventions preferred by intermediate-grade students. One hundred four fifth and sixth grade students, representing categories of "good" and "poor" readers, were randomly assigned to four reading conditions. In each condition, students read a series of six passages and answered comprehension questions after each. Three of the passages were of "low" difficulty and three of "high" difficulty. The first treatment group used only paper and pencil, the second had the materials delivered via microcomputer, the third added automatic computer display of various types of remediation whenever the students had difficulties, while the fourth treatment allowed the students to select particular computer-delivered remediation options when they had difficulties. On high difficulty items, the automatic computer remediation was most effective. Low difficulty passages were answered more successfully using paper and pencil than they were when students were allowed to select their own computer-delivered remediation. Again, automatic computer remediation was also effective and significantly more so than student-controlled remediation.

Another reading test given one week after the experiment showed no difference among the good readers regardless of which reading condition they participated in. But poor readers who had only used pencil and paper did significantly better than poor readers who had selected their own computer remediations. The researchers suggest that intermediate-grade readers are not adept "at managing the contingencies of their reading" and therefore not well able to benefit from being allowed to make their own choices about hints and remediation. Computer control of hints and help seemed desirable, especially for difficult material. In addition, the "novelty" of reading text on a computer may even interfere with comprehension on low-difficulty passages. The study did show that, when the students were allowed to select remediations, they did so freely but preferred to choose the option of "requesting background information" more than they chose "vocabulary hints," "reading an easier version," "seeing the main idea" or "rereading the passage."

Patterns in Learner Control

Rubincam, I. & Olivier, W. P. (1985). An investigation of limited learner-control options in a CAI mathematics course. *AEDS Journal, 18*(4), pp. 111-116.

One of the ways in which learners can control their sequence of interaction with a tutorial/drill program is to decide initially if they wish to move directly to drill or if they first wish to work through a tutorial segment. This study allowed 139 students in grades nine through 12 to make this decision as they interacted with an eight-part "coordinates and transformation" geometry course offered on computers. Among the findings of this study are that the students spent the majority (60 percent) of course time on testing, allotted only 37 percent to instruction and practice, and chose to spend very little time (2.6 percent) on the optional games offered at the end of each of the eight sections. Also, the majority of the students were consistent in their choice of instruction-first or test-first strategies, their choices did not seem to relate to their previous pretest scores, there was no difference in performance between those who went immediately to testing and those who studied tutorial material first, and students did not alter their "learner-control choices even when it might be appropriate for them to do so at the topic or objective level." This suggests that response sets are present in students' approaches to computer-based instruction. The authors argue that these reflect a caution-confidence dimension that affects students' ability to make effective learner-control decisions.

RESEARCH WINDOWS

Betty Collis

This month's Research Windows includes a study examining the impact of computer simulations with remediation on students' misconceptions about velocity, and another study investigating the impact of The Factory and a space exploration game on the spatial skills of intermediate students. A third study reports on the impact of a "microcomputer learning project" on a number of variables such as divergent thinking, self-confidence, and reading and mathematics achievement. The final two studies consider the impact of various factors on the way teachers develop and demonstrate computer-using competencies.

Impact of Velocity Simulations

Zietsman, A. I. & Hewson, P. W. (1986). Effect of instruction using microcomputer simulations and conceptual change strategies on science learning. *Journal of Research in Science Teaching, 23*(1), pp. 27-39.

Students' "alternative conceptions" about scientific concepts are "resistant to change by exposure to traditional instructional methods" (p. 28). One such alternative conception relates to velocity, where students typically use a "position criterion"—assuming that two objects have the same velocity when they are next to each other—to decide when velocities are equal. In this study, groups of grade 8 students and university freshmen were randomly assigned to either a computer simulation which presented six simulated motion situations, or the same simulation with the addition of specific remediation sequences which helped the students see that a position criterion was not always an appropriate test of velocity equivalence. The students using the computer remediation in conjunction with the simulations did significantly better on a posttest than the students who only interacted with the computer simulations. This study gives us more evidence that computer simulations can have an impact on concept acquisition *if* the simulations are embedded in an environment that helps students learn from them.

Developing Spatial Abilities

McClurg, P. A. (1985). *A study of the effects of playing selected microcomputer games on the spatial ability of fifth, seventh, and ninth grade males and females.* Unpublished doctoral dissertation, University of Oregon.

Many educators wonder if there is educational value to be had in students using a "problem solving" software package or in playing a computer game involving spatial ability. In this study, 57 students were randomly assigned to groups which, over a six-week period, interacted with *The Factory*, or with *Stellar-7* (a space game), or had no computer activity at all. Students were tested before and after on various measures of spatial visualization and orientation. Males and females at all three grade levels benefitted from the two computer experiences. Students interacted more with each other during their use of *The Factory* than they did during their use of the space game, where "no student chose to share a computer with another student . . . although students were free to do so" (p. 80). There were no overall sex differences in improvement. However, fifth grade females scored higher than fifth grade males on the posttest measures of spatial ability while seventh and ninth grade boys outperformed seventh and ninth grade girls. Intra-sex variation was more pronounced than inter-sex variation. The study supports the positive impact that computer games involving spatial perception can have on students' overall spatial ability.

Gifted and Average Students and Computer Use

Millar, G. & MacLeod, A. (1984). *Microcomputer learning project: Willowcreek School Division,* Planning Services Branch, Alberta Education, 11160 Jasper Avenue, Edmonton, Alberta.

Gifted and "average" students participating in various computer literacy activities were compared with each other and with students in another school district who were not involved in computer use. The computer-using students gained more than the comparison groups on a test of divergent thinking and on a reading comprehension test. However, there were no particular differences in the groups in various mathematics measures or on different tests measuring self-confidence. It is not clear from the report how long the microcomputer learning project lasted; it seems to be one full school year.

The most interesting observation related to the study of programming. The evaluators note that the gifted students exhibited great interest and accomplishment in programming, compared to the average students. They recommend that programming be encouraged as an experience for gifted students because of the divergent thinking it promotes, but that schools should be "cautioned against" having "high expectations" for programming for average students.

Factors Influencing Computer Use

Carey, D. M. (1985). *An investigation of factors that affect elementary school teachers' educational use of computers.* Unpublished doctoral dissertation, University of Oregon.

What is a good predictor of the amount of time a teacher will spend with his or her students on instructional activities that involve the use of computers? In this study, 39 fourth, fifth and sixth grade teachers, all of whom had received prior training in computing through university credit courses or district inservice, were examined to see what distinguished teachers who made little use of computers from those who made more substantial use. Attending a university course was a good predictor of classroom use, whereas no significant correlation was found between hours of district inservice training and subsequent classroom computer use. The availability of a computer at home for school-related work was found to be a strong predictor of a teacher's instructional usage, as was "proximity of the school's computers to the teacher's teaching area." These are interesting correlations, in that they show "chance variables" can affect what happens in the classroom. In addition, "the study also found that teachers believe that the principal is the most influential person in their decision to implement computing" (p. iv).

Comparing Methods of Teacher Training

Cooper-Shoup, S., Farris, P. J. & Higgins, J. E. (1985). *A Comparison of computer literacy delivery systems at the preservice teaching level.* Unpublished manuscript, Northern Illinois University, DeKalb, Illinois.

Finding the most efficient and effective method for providing teacher training in the educational use of computers is an important issue. One major decision involves the choice between training teachers through a self-contained course, or devising a way that will allow teachers to receive their training independently and outside of a course structure. In this study, 17 preservice elementary education teachers who were enrolled in a "computers in education" course were compared with 23 preservice teachers who worked through six "individualized, self-paced tutorial programs" (described in *The Computing Teacher, 12*(3), 1984). All students were pre- and posttested on various "computer literacy" skills and understandings. The self-paced tutorial group did significantly better on the posttest than the students who took the "traditional" computer literacy course, suggesting that a well-designed self-pacing package can be a cost-effective alternative to the practice of staffing, rooming and offering a traditional "introduction to computers in education" credit course. The major frustration in this article is that neither the self-paced materials nor the content of the "traditional course" is directly described.

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1986-1987

RESEARCH WINDOWS

Betty Collis

In this month's *Research Windows* we examine an interesting variety of studies. One describes the effect of mathematics software which provides diagnostic feedback on 80 common computational errors, and another looks at the relative impact of Logo and BASIC on gifted students' problem solving skills. The remaining studies: explore the effect of a person's learning style on how the person searches a data base; demonstrate the gender stereotyping present in computer magazine advertisements and illustrations; and summarize research on CAI effectiveness relative to secondary school achievement.

Diagnostic Feedback in Mathematics

Janke, R. W. & Pilkey, P. J. (1985). Microcomputer diagnosis of whole number computational errors *The Journal of Computers in Mathematics and Science Teaching, 5*(1), pp. 45-51.

The software used in this study contained examples of 80 common errors made by students in solving addition, subtraction, multiplication and division operations involving whole numbers. (The common errors are described in the article, and should be of considerable interest in themselves for any elementary school teacher.) Over a 12-week period, 376 students in grades two through six took four paper-and-pencil tests involving whole number computation. The 29,392 problems and accompanying answers were entered into the computer and analyzed for error classification. Teachers in one school were told only the student and class averages for each test, while teachers in another school were also given specific diagnostic information about which common errors each student made and how many times the class as a whole made each type of common error. (It is interesting that 50.6 percent of the student errors were "basic number fact errors.") The children whose teachers received specific computer feedback improved more over the year in computation than the students in the same grades whose teachers were not given the diagnostic feedback. This difference was most strong in grades two through four. Teachers receiving specific diagnostic feedback indicated a better sense of the students' common misapprehensions, and visual demonstration of designated errors was judged to be a very effective learning experience for individual students.

This type of diagnostic feedback ought to be standard in drill software; this study supports the conviction that management systems only recording percentage correct at various levels should be redesigned or even rejected if they do not provide more purposeful feedback.

Gifted Students and Programming

Brown, S. W. and Rood, M. K. (1984). *Training gifted students in Logo and BASIC: What's the difference?* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Eighty gifted students, grades two through nine, were given the choice of enrolling in an eight-week BASIC or Logo course. The students were tested before and after the course on their self-esteem, locus of control, problem solving ability and computer knowledge. Although the students as a whole significantly improved their scores on the problem solving ability and other vari-gramming experiences, there were no differences between the Logo and BASIC students. Also, the students increased in self-esteem and in internal locus of control after the programming experiences, but just as much in the BASIC group as in the Logo group. These results should be examined by those who disparage BASIC and extol Logo because of its potential impact on problemsolving ability and other variables. The researchers comment that the act of working with a programming language may be what delivers critical benefits, at least to gifted children, rather than the features of one particular language compared to another. (Dr. Rood is now at Asnuntuck Community College, Enfield, Connecticut.)

Data Base Search Strategies

Hedberg, J. G. & Perry, N. R. (1984). *Teacher cognitive styles and selection of computer courseware.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Although the title of this paper does not indicate it, this study is primarily an examination of the search strategies employed by 77 undergraduates using data bases containing abstracts of 230 educational programs for mathematics and biology. Some of the records were organized around keywords while others were not. The researchers were particularly interested in how an individual's degree of field dependence or independence predicted the way s/he would access a data base for information. ["Field independent" people typically find it easier than "field dependent" people to focus on a relatively simple compo . imbedded within a complicated whole.] Although their results were mixed, the researchers did find that students who were more field independent searched a data base more quickly and efficiently than field dependent students, and used more complex search strategies. The amount of prior experience with computers seemed a more important variable than cognitive style, however. Computer-naive people (presumably at the "parrot" and "novice" levels, described on p. 2 of the article) "found interrogation of on-line information systems difficult, and approached such tasks with a high level of anxiety . . . employing only the simplest functions of a data base query system despite training on the available range of functions."

This is a valuable observation in light of the many suggestions for data base development and accessing in a classroom context which now frequently appear. (The authors are in the Faculty of Education, Western Australian Institute of Technology.)

Gender Typing in Magazines

Ware, M. C. & Stuck, M. F. (1985). Sex-role messages vis-a-vis microcomputer use: A look at the pictures. *Sex Roles, 13*(3/4), pp. 205-214.

The study explored the ways that men, women, boys and girls were pictured in three mass-market computer magazines. Many stereotypic gender portrayals were found in the 426 illustrations which were analyzed. Males appeared in 69 percent of the illustrations, although they are, of course, only half the population. When females were in an illustration, they were just as likely to be only watching someone else using a computer as they were to be active users themselves, whereas 78 percent of the males portrayed were actually involved with using a computer. Boys were shown as game players in 20 percent of the illustrations including boys. Girls (17 and under), however, only appeared in the illustrations as learners, never as game players or in other computer-using roles. This study has serious implications for educators who are committed to the development of more positive attitudes toward computers among females. We are fighting a difficult battle in schools in our efforts to make our female students see themselves as competent computer users when the powerful world of advertising is clearly portraying computers as belonging in a male-dominant environment.

Summary of CAI Effectiveness

Samson, G. E., Niemiec, R., Weinstein, T. & Walberg, H. J. (1985). *Effects of computer-based instruction on secondary school achievement: A quantitative synthesis.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago.

This report gives the results of a meta-analysis of 43 published studies, each comparing some form of curriculum-related computer-based instruction with traditional instruction in grades seven to 12. Some of the results of this summary of the studies are especially interesting. In general, computer-based instruction was associated with greater gains in performance when compared to ordinary instruction (38 of the 45 studies) and was most effective with students from urban, inner city schools and in studies "with lower socioeconomic level students, black students and with students of below average achievement." Computer materials developed locally by the researcher or by groups of teachers were more effective than commercially developed programs. One result stands out: Studies where the computer use was of short duration (two weeks or less) produced stronger positive differences compared to regular instruction, but this short-term advantage was not maintained when computers were used for approximately one semester. This reminds us of the strength of the novelty effect when computer use is first introduced and warns us to scrutinize published computer-based instruction research for length of treatment before giving strong consideration to the results. (For those who would like further information about the study, Samson is at Cleveland State University.)

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RESEARCH WINDOWS

Betty Collis

Group vs. Individual Computer Use: Preschool Children's Preferences

Swigger, K. M., & Swigger, B. K. (1984). "Social patterns and computer use among preschool children." *AEDS Journal, 17*(3), pp. 35-41.

For three consecutive weeks, a detailed log was kept of how often and in what ways 44 preschool children chose to interact with computers available for free use in their nursery school classrooms. The results are very interesting. Half of the children made very little use of the computer (defined as less than 45 minutes total over three weeks), and none of the children used the computer alone despite the fact that the software available to them was designed for single users and a one-child-at-a-time rule had been originally established. Children persisted in coming to the computer in groups of two or three, with the most typical arrangement having one child operate the keyboard while the other children watched. All of the children used the computer with their close friends and its presence did not disrupt the predefined social groups in the classes. Only a few children made new groupings based on apparent computer interest; virtually all self-selected groupings reflected prior friendship patterns. These data are very interesting, showing that not all young children will automatically want to use a computer even when available, and more importantly, that we would be well-advised to organize computer use around a group context and to let children select their own computer partners.

Group vs. Individual Computer Use—Impact on Achievement

Webb, N. M. (1985). "Cognitive requirements of learning computer programming in group and individual settings." *AEDS Journal, 18*(3), pp. 183-194.

This study also involves the investigation of group versus individual work with computers, but instead of studying children's preferences, the research examined the impact of group work on achievement in computer programming for 11- to 14-year-old students. Unlike the previous study, children were randomly assigned to individual study or paired-study procedures. The 55 students involved were volunteers who attended a three-hour workshop in BASIC and were paid five dollars for participating. Given the shortness of the treatment and the fact that the students in the paired group were not allowed to choose their partners, it is not surprising that no difference was found between the group and individual learning settings on any programming outcomes. However, the study does give us some interesting results. Cognitive abilities of various types were less important predictors of success in a group setting than they were for students working individually. This supports other research that suggests that interaction among group members can become as important as individual ability when learning programming.

Science Teachers and Computer Use

Reid, M. I. (1986, May). "Male and female science teachers' use of microcomputers." Paper presented to the World Congress on Education and Technology, Vancouver, British Columbia.

A large sample of secondary school science teachers was surveyed regarding their use of computers in instruction. Although nearly all of the teachers indicated they had access to computers in their schools, fewer than half of them acknowledged ever attempting to use a computer in an instructional context. What I found most interesting about this study were the differences it revealed between male and female biology teachers in computer usage. While there were no differences in the proportions of male and female chemistry and physics teachers who reported using computers, a large and significant difference was found between male and female biology teachers' use, with these females indicating very little use. The percentage of male science teachers using computers did not differ, regardless of the science area taught. But female chemistry and physics teachers were very different from female biology teachers in computer use; an interesting observation to add to the puzzle of why so many secondary school females reject computer use or studies.

Dr. Reid is with the National Foundation for Educational Research in England and Wales, The Mere, Upton Park, Slough, Berkshire, SL1 2DQ, U.K. Although the research was conducted in Britain, I suspect its findings would be much the same in many North American settings.

Identifying and Training Visual Problems Associated with Reading Disabilities

Grisham, J. D., & Rubin, D. (1985). *Computerized Vision Training*. First Annual Report, American Institute for Research in the Behavioral Sciences, P.O. Box 1113, 1791 Arastradero Road, Palo Alto, CA 94302.

Many reading disabled children have visual neuro-muscular deficiencies that result in inefficient eye coordination and binocular vision. These problems can cause sufficient eye discomfort so that reading becomes something to avoid. This study examined the use of a specialized computer system (called CATT) to identify and improve vision skills of children who are having reading difficulties. The CATT system was effective in identifying vision problems and was alsc effective in significantly improving the "accommodative" and "fusion" facilities of children with these types of vision problems. However, no particular impact on reading achievement accompanied these vision skills gains. This may well be a function of the relatively short time of the study (10 weeks). Interested special educators or reading specialists should contact the authors for information about the second year of this study. The aim for the second year is to develop software that will accomplish this type of testing and training on computer systems already available in schools.

RESEARCH WINDOWS

Betty Collis

This month's "Research Windows" highlights five studies, four of which were presented at the National Educational Computing Conference, held in San Diego, June 4-6, 1986. Three of the studies describe valuable insights into word processing and writing, the fourth relates to gender differences in attitudes about computers, and the fifth discusses the lack of impact of a simulation program on concept learning.

Writing Errors with Word Processing

Daiute, C. (1986, June). *Instrument and idea: Some effects of computers on the writing process.* Paper presented at NECC '86, San Diego. (Daiute's address is Harvard University, Graduate School of Education, Cambridge, MA).

Do junior high students make and correct different types of errors and make different types of revisions when they use word processors compared to when they use pens? Is their writing more error free? Daiute introduced 71 students to keyboarding and word processing and observed their use of a word processor over a school year, where each student had at least one class period per week at the computer. She compared computer and pen writing from each student and found that students had the same initial error rate in each medium (crossing out words in pen as readily as they used the computer editing features), but corrected a higher percentage of errors on computer than by pen when they worked on subsequent drafts. More importantly, they made different types of errors in the two media. Using a computer was associated with more mechanical errors (mostly punctuation errors, possibly related to the positions of the punctuation keys or to the 40-column display present in this study), more sentence fragments, and more "empty" words than pen writing. Daiute suggests that the empty words may resemble speech more than traditional writing and that "the production mode of the computer (with its fluid and maleable text)" may be in some ways more like the production mode of speech than it is like pen writing. This has many implications, particularly in studies where writing samples from the two modes are directly compared.

Reading Efficiency and Word Processing

Haas, C. & Hayes, J. R. (1986). "What did I just say?" Reading problems in writing with the machine. *Research in the Teaching of English, 20*(1), pp. 22-35.

Reading is an important part of the writing process. This study explored the possibility that reading is slower and less efficient on the computer than from print and that this has an impact on writing with a word processor compared to writing with pencil and paper. The researchers, using university students who were all experienced in word processing, found that readers apparently had better "spatial memory" of the location of specific sentences within a multi-page document when it appeared in print than they did when they read it on a monitor. Readers, on the average, could find a particular sentence in 13 seconds in a printed manuscript, but took 32.7 seconds to find the same sentence in the same text presented as a word processing file. The study also found a considerable advantage in speed and accuracy for paper and pencil over word processing when students were asked to reorganize a disordered text. The paper and pencil advantage disappeared, however, when students used a large (19") high-resolution, black-on-white display for their word processing. These are valuable findings; they suggest that some aspects of computer-displayed writing may make revision less productive when done on the computer than when done with traditional tools. The researchers conclude by suggesting teachers may want to encourage students to make use of hardcopy rather than on-screen text for revision and editing when using a word processor without "advanced" screen displays.

Collaborative Writing and Word Processing

MacGregor, S. K. (1986, June). *Computer assisted writing environments for elementary students.* Paper presented at NECC '86, San Diego. (MacGregor's address is Department of Administrative & Foundational Services, Louisiana State University, Baton Rouge, LA.)

In this interesting study, 100 sixth graders participated in various writing environments: paper and pencil, independent use of a word processor, working in pairs at a word processor, and using "writing-prompting" software. Students' writing was appraised with paper and pencil before and after the 10 weeks of treatment. Word processed pre- and poststudy samples were also obtained from the computer groups. Children using the computers showed significantly greater improvements in measures of writing mechanics, spelling accuracy, word usage and narrative length than the children using only paper and pencil. Children using the story starter program did indicate more instances of cause and effect relationships in their writing than did the other children, but also had more instances of run-on sentences. Most interesting are the results when children working in pairs at the computer are compared to other children. Children working in pairs at the word processor made fewer mechanical errors than children working individually, and this differential was maintained in the paper-and-pencil posttest, which was written independently by all the children. However, the paper-and-pencil narratives of children who had worked in pairs were significantly shorter when they wrote independently than were the narratives of children who had worked independently all along. This may suggest both positive and negative developments associated with collaborative writing on the word processor, and that a mixture of both types of experiences is probably desirable.

Sex Stereotyping and Computers . . . Again

Smith, J. (1986). *Computer attitude survey of eighth grade students.* Unpublished Master's thesis, Seattle Pacific University, Seattle.

In 1984 *The Computing Teacher* published the results of a survey I had done investigating sex differences in secondary school students' attitudes toward computers. My study found boys to be significantly more positive and confident than girls about computer use, while girls were more likely than boys to believe females can be as computer competent as males. Nearly three years later, Ms. Smith has conducted the same sort of study with 979 eighth grade students and, unfortunately, has found the same general results. In her study, boys are still more confident and more positive about computer use and significantly less likely to believe girls can do as well as boys with computers. Although computer opportunities in schools have increased for all students and many people have addressed the gender-difference problem with regard to computer access and confidence, Ms. Smith's study and others like it show us that the basic situation may not have changed. The encouragement of females to be confident and positive computer users is still of major importance in schools and society.

[Editor's note: Doesn't the question, "Can girls do as well as boys with computers?" suggest it's normal to think they can't? Perhaps it even reinforces the belief. The question, "Can boys do as well as girls with computers?" should also appear in such surveys.]

(In)effectiveness of Simulations

Waugh, M. L. (1986, June). *The effect of teacher involvement on student performance in a computer-based science simulation.* Paper presented at NECC '86, San Diego. (Dr. Waugh is at the University of Illinois, 1310 South Sixth Street, Champaign, IL.)

Average and below-average eighth grade students interacted with the simulation *Volcanoes* for a total of three hours over four days with two different types of teacher intervention: involved or non-involved. The extent of teacher intervention had no effect in this study, as all children indicated they enjoyed the simulation experience but neither group indicated they learned much about volcanoes from the interaction (the average mean posttest score in both groups was only 55 percent). The author notes a number of possible explanations for this disappointing achievement level, all of which are pertinent to the evaluation of other simulation programs. First, the student manual gave a great deal of information but with little discernible relationship to successful completion of the simulation. Second, the program was advertised as appropriate for grades seven through 12, but readability analyses showed it to be at the grade 12 level. Third, the scoring system used within the simulation was not explained and all players were penalized for a poor entry by any one player, creating a sense of uncertainty and discomfort. Fourth, feedback was not adequate to help students develop a successful strategy or to know how well they were progressing. A fifth explanation is more problematic; perhaps students who are not above average will have difficulty utilizing simulations regardless of teacher involvement or components of the simulation.

RESEARCH WINDOWS

This month's "Research Windows" includes four studies relating to science simulations and one supporting the value of a data base management program in secondary social studies. The science studies, taken together, give us insights into the effective use of computer simulations in any instructional context. The social studies study can be similarly generalized to other instructional settings.

Long-Term Impact

DeClercq, B., & Gennaro, E. (1986, March). *The effectiveness of supplementing the teaching of the volume displacement concept with use of an interactive computer simulation.* Paper presented at the 59th Annual Conference of the National Association for Research in Science Teaching, San Francisco.

Students in four ninth grade science classes were taught a traditional unit on volume displacement concepts. Following the regular instruction half of the students were given the opportunity to spend an additional 10 to 20 minutes using a computer simulation that allowed them to replicate some of the laboratory experiences they had already done in class (predicting the new level of liquid in a graduated cylinder when various objects were placed in the liquid). After 55 days and no additional discussion, all students were given a posttest on volume displacement. The students who experienced the short computer simulations did significantly better than those who had not. Both low- and high-ability students in the computer group showed substantial improvement. These are encouraging results, in that a "modest investment" of time using a simulation that consolidated laboratory experiences resulted in a convincing demonstration of effective long-term impact on student understanding. (DeClercq can be contacted at Chicago Lakes Area Schools, Lindstrom, MN 55045.)

Value of Corrective Feedback

Zietsman, A. I., & Hewson, P. Q. (1986). "Effect of instruction using microcomputer simulations and conceptual change strategies on science learning." *Journal of Research in Science Teaching, 23* (1), pp. 27-39.

In this study, a simulation of a real experiment was used to identify the different conceptions students had concerning the relative motion of two balls on a sloping rail. Apparently many students assume that two balls are moving at the same velocity when they are next to one another; they use a "position criteria" to decide when velocities are equal. Those who used a simulation which anticipated this common alternative conception and gave remedial instruction when it was displayed, corrected their misconceptions to a significantly greater extent than those students who used the simulation without these remedial comments. Students who only manipulated the simulation without this help showed no improvement in their understanding. This supplies more evidence that students benefit when purposeful, corrective feedback is given while they use a simulation. Simulations should do more than just allow students to replicate an experiment; they need to respond to common misconceptions which otherwise tend to be resistant to change.

Haphazard Manipulation of Variables

Stevens, S. M. (1985, April). *Surrogate laboratory experiments: Interactive computer/videodisc lessons and their effect on students' understanding of science.* Paper presented at the 58th Annual Conference of the National Association for Research in Science Teaching, French Lick, Indiana.

This study is interesting because it documents differences in the way students manipulate variables when they use a computer simulation compared with when they do the same experiment in the laboratory. The experiment involved vibrating strings. Students in the lab were observed to systematically alter one variable at a time—either size of string, length of string, or tension on string—before they manipulated a second or a third variable. Students using the computer simulation were "haphazard" in their manipulation of variables and seemed to respond more to the arrangement of input prompts on the monitor than to any awareness of the need for systematic separation of variables. However, there was no difference in achievement between the two groups of students on a posttest, which suggested to the author that the students in the lab were only being superficially systematic, not because of a better sense of the importance of systematically considering the effect of each variable, but because of the physical convenience of manipulating one variable at a time in the lab environment. Again, it is not good enough to expect students to apply "scientific thinking" to an experimental situation; guidance needs to be given, either in the lab or during the use of a simulation, to help students see underlying patterns. (Stevens can be contacted at 4620 Henry Street, Pittsburgh, PA 15213.)

Simulations Before and After Instruction

Finley, F. N. (1986, March). *Learning from science computer simulations.*

Paper presented at the 59th Annual Conference of the National Association for Research in Science Teaching, San Francisco.

This study involved videotaping students who used a computer simulation of geological concepts before and after they studied material relating to the topic of the simulation. By examining what students said and did and what they indicated they were thinking during the simulations, the author obtained some useful observations. First, students who were not already knowledgeable in the area "learned very little" from initial use of the simulation. However, they did become more aware of what they needed to know about the situation and apparently were more attentive to this particular information when they subsequently studied text material. When the students used the simulation again after studying the material, they were much more effective in both their reasoning and performance. There seems to be a good teaching idea here regarding the classroom use of simulations. Perhaps we should plan for students to interact with a simulation at two distinct times: before a unit of study to sensitize them to the variables that are important in the system they will be studying; and then after they have studied the material so that they can consolidate what they have learned. (Finley can be contacted at the University of Maryland, College Park, MD 20742.)

Data Bases and Process Skills

White, C. S. (1985). *The impact of structured activities with a computer-based file-management program on selected information-processing skills.* Unpublished doctoral dissertation, Indiana University.

This study is valuable for two reasons. First, it gives clear support to the learning value of augmenting secondary school social studies coursework with student use of a data base management system and a data base of relevant material. Second, it includes a 16-question paper-and-pencil test that appears to be a valid measure of some important but hard-to-measure "process" objectives that I believe can be strongly influenced through use of a data base management system within a curriculum context. These objectives are: evaluating the relevance of data for a given problem situation, evaluating the sufficiency of data for a given problem solution, and identifying ways of organizing data that will generate the most or best information for solving a given problem. White involved 14 secondary social studies teachers, each teaching two classes (a total of 665 students). All the classes covered the same material; but for each pair of classes, one used Scholastic's *pfs: Curriculum Data Base in Social Studies*, and the other had no computer interaction. The computer-using students scored significantly higher on the 16-question "information processing" test than did the students who did not interact with the data bases. (White can be contacted at the Computer Literacy Center, Indiana University-Bloomington, Bloomington, IN 47405.)

RESEARCH WINDOWS

In this month's "Research Windows" we examine two Logo-related studies and a study which looks at the connection between programming and thinking skills. We finish with two that examine the impact of different types of computer activities on achievement.

Logo: Limited Impact

Horner, C. M., & Maddux, C. D. (1985). "The effect of Logo on attributions toward success." *Computers in the Schools, 2* (2/3), pp. 45-54.

In the first of the Logo studies, four junior high school classes, two of which were classified as learning disabled, were divided into two groups. The treatment group (one regular class and one learning disabled class) participated in 14 sessions of Logo activity, each lasting 55 minutes, while the control group received regular mathematics instruction. There were no significant differences between Logo and non-Logo students, either regular or learning disabled, in tests of problem solving skills or recognition of size of geometric angles, or in their attitudes toward mathematics after the treatment period was over. The researchers suggest that this might be because the Logo students "were not told what [math] concepts they were learning" or even "that they were learning mathematical concepts" during the Logo activities (p. 51).

One positive finding did occur. After the Logo experience, the majority of the Logo-using students indicated they felt their own efforts and ability determined their success with Logo programming, even though a number of them had indicated before the study began that luck or external factors might be responsible for their success in a task. The authors conclude that Logo may help students assume a greater degree of personal responsibility for their own work, and may help them generalize this sense of personal "attribution toward success" to other academic areas.

Logo: Any Lasting Impact?

Siann, G., & Macleod, H. (1986). "Computers and children of primary school age: Issues and questions." *British Journal of Educational Technology, 17* (2), pp. 133-144.

Fifteen children in Scotland (average age six years) participated over a period of five months in intensive Logo use. They were introduced to a simplified version of Logo using both a floor-crawling Turtle and a screen Turtle, and were described as making considerable gains in various skills. Then, in this current study, taking place during the following academic year, seven additional children joined the class. The purpose of this study was to see if a researcher, who did not know any of the children, could identify the Logo-experienced children from those who had had no Logo exposure. The researcher interviewed the children and gave each a series of tests.

The results are striking. The researcher was unable to distinguish the Logo children from the non-Logo children, either through the interviews or on the basis of performance on tests of picture completion, laterality, or map-reading skills. When the children were asked to tell any interesting things they had done or played with at school, only one of the Logo-using children mentioned the computer, Turtle or Logo. In addition, the researcher noticed that the Logo children would use the LEFT and RIGHT keys at random until the Turtle headed in the desired direction, rather than understanding the left and right sides of the Turtle and its relationship to their own left and right sides. This is the sort of follow-up study that should be done much more often; what a good idea to see if an outsider can distinguish students who have had a computer-based learning experience from those who have not.

Programming as Mental Exercise

Mayer, R. E., Dyck, J. L., & Vilberg, W. (1986). "Learning to program and learning to think: What's the connection?" *Communications of the ACM, 29* (7), pp. 605-610.

Does programming improve thinking skills? This question has often been asked (or assumed to be answered in the positive). This series of studies examines the relationship more carefully. University students who took a beginners' course in BASIC were compared to a group of students with no programming exposure. The BASIC group gained significantly more than the comparison group on two of the eight thinking-skill tasks given, but no significant differences occurred between the two groups on any measures of general thinking ability. The improvement was on tasks that had a specific relationship to programming (problem translation and procedure comprehension). The researchers also gave a second group of students some direct instruction in procedural thinking before they began programming. This "pretraining" resulted in their learning BASIC more quickly and successfully than students without the pretraining. The authors conclude that programming experience can both influence and be influenced by specific thinking skills that are directly related to the programming tasks, but "that there is no convincing evidence that learning to program enhances students' general intellectual ability, or that programming is any more successful than Latin for teaching 'proper habits of mind'" (p. 609).

Coordinate Graphing Games

Morris, J. P. (1983). "Microcomputers in a sixth-grade classroom." *The*

Arithmetic Teacher, 31 (2), pp. 22-24.

This study is more encouraging. Two sixth grade classes were taught a unit on coordinate graphing by the same teacher over the same four-week period. One of the classes had two microcomputers in the classroom, and children in that class went in pairs to the computers to play each of three simple games involving coordinates. Each pair played each game two times. The children did this without the teacher needing to alter the regular lesson. At the end of the unit the children using the computer did significantly better on a test of coordinate graphing skills than did the children in the other classroom. The teacher, who was inexperienced with computer use, was pleased that it was a "simple and straightforward" process to fit computer use in without disrupting regular instruction and that its use motivated the children and engaged them in problem solving strategies.

The games they played were simple BASIC games—"Pizza," "Mugwump" and "Depth Charge"—typed in from magazine listings. This is even more encouraging, showing that a good instructional idea does not have to be accompanied by a costly software purchase. Now that educational software is typically made to a high technical standard, I wonder if teachers still use the simple little BASIC programs that started many of us off as enthusiastic computer users in the early days of computers in the classroom?

Learning Disabilities and CAI

Harper, J. A., & Ewing, N. J. (1986). "A comparison of the effectiveness of microcomputer and workbook instruction on reading comprehension performance of high incidence handicapped children." *Educational Technology, 26* (5), pp 40-45.

Nine junior high school special education students who required remediation in reading comprehension skills spent four weeks alternating between computer-based reading comprehension exercises and similar exercises in workbooks. The computer was the most effective treatment in terms of "productivity" (number of comprehension questions answered correctly) for eight of the nine students. The researchers did not see any difference in the attention that the students gave to the computer and workbook activities, suggesting that the students were not simply more motivated by using a computer. Eight of the students also indicated that they preferred the computer to the workbook and that they learned more from the computer. Considering that the students were reluctant readers with prolonged histories of reading problems, these results are quite encouraging.

RESEARCH WINDOWS

In this month's "R...earch Windows" we look at two studies from a set investigating computer-assisted instruction and mildly handicapped students. We also highlight a study about touch typing and elementary school students, another about preschool children and the impact of a computer on their story telling, and a more general study exploring the types of computer experiences likely to be valuable in terms of students' future job possibilities.

Considerations in CAI for Mildly Handicapped Students

Woodward, J., Carnine, D., Gersten, R., Gleason, M., Johnson, G., & Collins, M. (1986). "Applying instructional design principles to CAI for mildly handicapped students: Four recently conducted studies." *Journal of Special Education Technology* (at press).

Study 1: Drill

Different groups of high school students classified as mildly handicapped participated in a series of investigations of different aspects of computer-assisted learning. In one study, the researchers studied the impact of teaching new vocabulary using a computer-only approach employing either a "Small Teaching Set" program or a "Large Teaching Set" program. Both progr... involved the same 50 words, but differed in that in one (the "small" set), the words were studied in groups of no more than three at a time, while in the other (the "large" set), a larger group of words was under focus at any given time. Ten of the 12 students using the small set learned the 50 words by the end of 11 sessions at the computer, and they did so in an average of 7.6 sessions. Eight of the 12 students using the large set also reached mast... in a mean of 9.1 sessions. There was no difference between the groups on either a posttest at the end of 11 weeks or a maintenance test two weeks after the posttest. The researchers believe it is valuable that the same mastery and retention gains can be sustained after a shorter period of computer time by mildly handicapped students in a drill situation where a smaller instruction set is under consideration, compared to a drill situation where the student has more learning stimuli to consider.

Study 2: Tutorials

In a second study, the researchers investigated the feasibility of using computer tutorials teaching reasoning skills with mildly handicapped middle school students. Twenty-eight mildly handicapped and remedial students were randomly assigned to one of two tutorial learning situations, both of which used the same computer program to focus on drawing conclusions and determining whether arguments were logical or illogical. The only difference in the two experiences was that one program offered "elaborated corrections" while the other only told the learner if an answer was right or wrong. Three interesting findings come from this study: (1) Students given remedial help when an incorrect answer was given did significantly better on various posttest and maintenance measures than those who were not given remedial examples; (2) students given remedial examples did not take any longer to complete the five tutorial sessions, despite being branched through remediation, than the students who had less reading to do; and (3) all the students learned from the tutorials and maintained their understanding at least two weeks after the sessions were completed. The latter result may be the most important: Mildly handicapped middle school students *can* learn from computer tutorials involving higher-order thinking and new material. Although many had only fifth grade reading levels and all had histories of learning difficulties, they were able to respond to abstract material delivered via a computer tutorial. Too often it seems that remedial students are given drill rather than new and challenging thinking opportunities when computer support is available.

More information about these studies and others in the series can be obtained from John P. Woodward, Follow Through Project, 1751C Alder Street, Eugene, OR 97403.

Keyboarding Instruction

Stoecker, J. W. (1985). *Touch-typing instruction in the elementary school: Current practice, a proposed research-based inservice program.* Unpublished doctoral dissertation, University of Oregon.

Educators from throughout Oregon were asked to describe their districts' activities with regard to typing instruction in elementary schools. Although a "majority" of the 217 respondents thought that grades three and four were the most appropriate for the introduction of touch typing, 53 percent indicated their districts currently do not introduce it until grades nine or 10. About 10 percent of the districts indicate they do offer formal touch-typing instruction in elementary schools. The majority of the respondents felt the classroom teacher was the most appropriate person to teach elementary children these skills.

Stoecker developed a series of lesson plans and a workshop to teach touch-typing, and reported on the improvement shown by the 135 children whose teachers attended the workshop. For example, 82 percent of the chil...en were using correct keying and attaining speeds of more than 15 words per minute after four weeks of keyboarding. Stoecker can be contacted about these materials at 4105 Oak Street, Eugene, OR 97405.

Dynamic Stories

Riding, R. J., & Tite, H. C. (1985). "The use of computer graphics to facilitate story telling in young children." *Educational Studies, 11*(3), pp. 203-210.

Will four-year-old children generate longer and more structured stories if they react to a sequence of computer-displayed pictures than if they only see a single picture as a stimulus or they are not shown a picture at all? Riding and Tite randomly assigned 60 children (30 boys and 30 girls) from two nursery schools to three groups and asked each child individually to tell a story about a dog. Twenty of the children were shown a picture of a dog, with a bowl, sitting on the grass and with a bird and the sun visible in the sky. Another 20 watched the same picture unfold dynamically on the computer. The third group received no picture stimulus. There were no gender differences in story length or structure, but the computer-visual children told significantly longer stories than the other 40 children. An interesting interaction was found with respect to story structure. Children in a nursery school in a predominantly upper-middle-class area responded particularly well to the computer experience compared to children in the second nursery school, located in a lower-socioeconomic-level neighborhood, even though there was no difference in story structures when the children in the two schools were compared in the two non-computer story environments. The authors surmise that the children in the higher SES school may have had more opportunity to be read to by their parents and consequently were better prepared to relate to the story structure suggested by the series of changes in the graphic displays.

Training for Future Jobs

Levin, H. M., & Rumberger, R. W. (1986). *Education and training needs for using computers in small businesses.* Report 86-SEPI-7. Stanford, CA: Stanford Educational Policy Institute.

Many people have argued that computer experiences in schools may lead to better employment prospects for students when they go into the work world. In particular, the heavy use of computers in offices and small businesses makes many parents and educators wonder if schools should supply some computer training in anticipation of students' future jobs. Levin and Rumberger surveyed people in nearly 3,000 small businesses with regard to their use of computers and what training they felt would be most useful in schools to prepare students for this computer use. "Most of" the respondents said that the application of computers in their businesses was "easy to learn," with an average of only about 30 hours of on-the-job training necessary. The business people felt that an emphasis on general communication, numeric and reasoning skills rather than a "technical orientation to computers" was the best way for schools to prepare students for computer use in their future employment situations.

RESEARCH WINDOWS

Betty Collis

This month's Research Windows *begins with reviews of two studies from a new book.* Young Children and Microcomputers, *edited by P. Campbell and G. Fein and published by Prentice-Hall. We also discuss a report on the impact of keyboarding instruction on elementary students; a summary of a CAI program used in Washington, D.C., elementary schools; and research on the cost-effectiveness of computer use in schools.*

Primary Children and Social Interactions

Borgh, K., & Dickson, W. P. (1986). "Two preschoolers sharing one microcomputer: Creating prosocial behavior with hardware and software." In *Young Children and Microcomputers*, pp. 38-44.

What sort of verbal and social interactions take place between young children working in pairs at a microcomputer? Ten pairs of children from age three to five interacted with an open-ended graphics-based alphabet program and with a drill-type program involving counting. All comments made by the children were tape recorded and analyzed. About 12 percent of all conversation involved discussions about turntaking. "Peer teaching" of some sort occurred more than twice as much with the drill program, and there was five times as much discussion about being "right or wrong' when the children used the drill program as when they used the open-ended program. Approximately 20 percent of the children's comments were not directed at each other, but were "nonsocial," either talking aloud about the task at hand, or talking to the computer "as if it were alive." The authors conclude that using either type of software package definitely did not result in negative effects on social interactions among the children, and that "the social interactions that take place among children using the microcomputer may be of greater educational significance than the interactions that take place between children and the microcomputer itself."

Computer Games and Aggressive Behavior

Silvern, S. B. (1986). "Video games: Affect, arousal, and aggression." In *Young Children and Microcomputers*, pp. 62-70.

Do computer games promote aggressive behavior in young children? Silvern discusses the results of various studies comparing the effects of different computer games and violent television cartoons on young children's behavior away from the computer. The results include a finding that playing a game such as "Space Invaders" and watching a violent cartoon both were accompanied by an increase in violent behaviors toward objects. Another interesting finding was reported: Children working in pairs at a supposedly cooperative computer game ended up displaying more aggression than children assigned to compete against each other in another computer game. The authors suggest that the "cooperative" game was frustrating for the children so they became cross and critical with each other, whereas the competitive game was easy enough that the children were not aroused by the situation. As usual in education, "simple" conclusions like "cooperative games are good, competitive games are bad" are usually not as straightforward as they seem.

Keyboard Instruction in Grade Four

Warwood, B., Hartman, V., Hauwiller, J., & Taylor, S. (1985). *A research study to determine the effects of early keyboard use upon student development in occupational keyboarding.* Research report prepared for the Office of Public Instruction, Helena, Montana. (Contact Mr. E. Argenbright, Superintendent).

Two classes of grade four children were given a pretest in keyboarding skills and then participated in eight weeks of instruction in touch-typing. During part of this instruction, the keys on the computer were covered with paper. The children were successful at using the appropriate fingering when they could not see the letters on the keys, and "did not revert to looking at the keyboard" when the keys were uncovered during the seventh week of instruction. The results are interesting. The 22 girls did significantly better on the pretest than did the 26 boys. The girls maintained their advantage over the boys at the end of the instructional period, but both girls and boys made significant improvements in their keyboarding skills. However, when the children were retested 40 days later, they all showed a significant *decrease* in their keyboarding skill, "a drop so profound that they were not keyboarding any differently than they had been at the beginning of the project." Without continuous training, the keyboard "learning" disappeared for these 10-year-olds.

Impact of CAI on Attitude and Achievements

Human Resources Research Organization. (1986). *Dolphin curricula in Washington, D.C.* 1100 South Washington St., Alexandria, VA 22314-4499.

HumRRO evaluated the impact of the Houghton-Mifflin "Dolphin Curricula" in reading, language arts and mathematics on children in 50 elementary schools in the Washington, D.C., area by comparing these children to children who were not using the Dolphin computer materials in 20 other D.C. schools. Eighteen different effects of the computer experience were examined, including its impact on achievement, attitude, and even absentee rate. All 18 measures were higher for Dolphin than non-Dolphin schools. These measures included principals' impressions and teachers' opinions. Not all the results were large enough to be statistically significant, however; in particular, there was no significant difference in student gain scores in reading and mathematics. Improvement in various attitude-related variables was strong. These results are encouraging, but just as encouraging is the decision made by Houghton-Mifflin to contract this type of independent and careful evaluation of its materials. We will all be better served when more software publishers contract evaluation studies as well as production and marketing activities when they commit themselves to the development of educational software.

Calculating the Cost of Computer Use

Levin, H. M. (1986). *Cost-effectiveness of computer-assisted instruction: Some insights.* Stanford Education Policy Institute, Report 86-SEPT-13. Stanford, CA 94305.

Measuring the cost-effectiveness of computer-assisted instruction is difficult because of great variations in computer usage from school to school and the difficulty of measuring costs in an educational setting. Levin, for example, compares various elementary schools using the same computer software and finds costs per student to range from $119 to $431. Perhaps the most interesting insight in this study relates to the assumption that hardware costs dominate the overall cost of CAI. Levin disputes this by noting that since 1984, hardware costs have generally been only about 11 percent of the overall costs of computer use. Software costs exceed hardware costs, and personnel costs "are a substantial and often neglected portion of CAI costs, accounting for about 40 percent of the total." This is important, for too often administrators may assume that funding for the computer *program* in a school is the same as funding for the *computers* in the school, whereas the real and hidden costs are substantially greater.

RESEARCH WINDOWS

by Betty Collis

This month's "Research Windows" features five studies: two which involve very young children; one on the beneficial effects of providing a cooperative framework to student use of a simulation; one which examines students' attention spans at the computer; and one comparing instruction in BASIC, Logo and PILOT on teachers' mathematics anxiety.

Novelty and Preschoolers

Goodwin, L. D., Goodwin, W. L., Nansel, A., & Helm, C. P. (1986). "Cognitive and affective effects of various types of microcomputer use by preschoolers." *American Educational Research Journal*, 23(3), pp. 348-356.

Preschool children were randomly assigned to three groups. Twenty-seven spent three 20-minute sessions, one per week for three weeks, under active adult guidance interacting with three programs whose aim was to drill letter matching and recognition. Twenty-six others used the same programs for the same amount of time, but without teacher intervention; the teacher, however, did show the children how to begin and remained in the room. The remaining 24 children had no computer access; unfortunately the study does not say whether they experienced comparable letter matching and recognition drills. There was no advantage, in terms of scores on various reading readiness measures, for the "computer" children compared to the control children before or after the computer experience. The author admits that the length of exposure to the computer activities may not have been long enough for real gains to occur. One finding is especially interesting, though. All the children were asked to rank-order a book, microcomputer and toy as to which they would like to play with most, next or least. Only 11 percent of the children who had been using micros with adult intervention chose the micro first, while 48 percent gave it last place. Nineteen percent of those who had used the micros independently chose the micro first while 62 percent put it in last place. But 42 percent of the children who didn't have access to a computer chose it first. After the study, when the control children were given their own chance to use the computer, their interest levels dropped. When they were asked to rank-order their play preferences for a second time after they had had computer experiences, only 25 percent chose the computer first. It seems that the expectation of access made the computer more attractive than it appeared once real usage occurred.

First Graders and Keyboarding

Phillips, S. E. (1986). *Computer Readiness in Grade One*. Unpublished master's thesis, University of Victoria, Victoria, British Columbia.

Four classes of first grade children were tested at the beginning of the school year with regard to computer-related vocabulary (identifying components of the computer system), computer operating skill (booting and interacting with a disk), and the speed and accuracy with which they were able to find and touch a key on the keyboard that would correspond to a letter shown on the monitor. Two of the classes of children then proceeded to participate in the *Writing to Read* program (IBM), which involves daily interaction with both a computer and a typewriter within the context of language arts instruction. The other children had no classroom computer access. After three months' time *all* the children, both *WTR* and regular classrooms, showed significant improvement in all the computer-related tests. However, the *WTR* group finished significantly higher than the control group in each case. There were no gender differences. This is interesting, as it demonstrates that young children are able to improve in keyboarding and other computer-related competencies even without regular computer access, but that regular access for first grade students can transfer to increased skills without any formal focus on those skills.

Another interesting finding of this study was the analysis of which keys the children found most quickly and accurately (A, G, P, S, T, X and Y) and which caused them the most difficulty (F, J, Q, B, H and W). This might be useful information for designers of software for young children as well as for teachers.

Cooperative Learning and Simulations

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1986). "Comparison of computer-assisted cooperative, competitive, and individualistic learning." *American Educational Research Journal*, 23(3), pp. 382-392.

The study compared the effects of computer-assisted cooperative, competitive and individualistic learning for 75 eighth grade students on achievement, oral interaction, attitudes toward computers, and perceptions of each other. The students participated in a 10-day instructional unit in social studies which included daily use of a computer simulation. The students assigned to the "cooperative" group were told their grades on the unit would be the average of the scores of the group members. The students assigned to the "competitive" group were told they would be graded based on their rank-order within their groups. Students in the "individualistic" group were told they would be graded based on how well they individually met preset standards. The results are fascinating. Students in the cooperative condition did more work, scored higher on achievement variables, reached a higher total of points on the computer simulation, spoke to each other more and in a more task-oriented fashion, and nominated more female classmates as desired work partners than did the students in the competitive and individualistic conditions. Males in the competitive group, however, indicated they "liked computers" more than any of the other groups. This study gives valuable support to the use of computer simulations within a cooperative framework in the classroom, even if boys didn't like it as much as they did in a competitive arrangement.

Attention Span at the Computer

Murphy-Berman, V., Wright, G., & Rosell, J. (1986). "Measuring children's attention span: A microcomputer assessment technique." *The Journal of Educational Research*, *80*(1), pp. 23-29.

Children in kindergarten through grade nine used a computer program to measure their attention spans and their abilities to focus on relevant information while ignoring irrelevant or distracting information, by pressing the return key every time a target signal on the monitor appeared within a boxed area. Children had two separate testing seminars, each lasting 20 to 30 minutes. During these sessions, observers coded any signs of restlessness. The children were also asked to describe how nervous or anxious they felt, and responded to several other self-report questions. The results indicated that performance improved with age until about grade five, and then leveled off. Also, boys had higher overall false alarm rates than girls, as they were more likely to impulsively hit the return key even when not appropriate. Boys also reacted more impulsively in general and talked and moved around more than did girls, results which were "remarkably consistent across grade levels." Visual distractors did not seem to affect the children at any grade level, as children "even at a very young age seem quite able to focus their attention on relevant stimuli" on the computer screen. Children's scores were not affected by nervousness or by prior computer experience, but were strongly related to overall individual activity level: Children who were typically restless were less likely to maintain attention at the computer than were typically attentive children. This result suggests that the hope that computer activities could engage the attention of students who are not typically involved in the classroom may go unfulfilled.

Programming and Math Anxiety

Signer, B. R. (1986). "An investigative study of possible effects of programming instruction on math anxiety and teacher attitudes toward CAI." *Journal of Computers in Mathematics and Science Teaching*, *5*(4), pp. 40-45.

In this study 51 teachers, enrolled in an off-campus computer education program, participated in 16-week programming courses. One course used BASIC while the other used Logo and PILOT. The level of mathematics anxiety of the teachers was measured before and after the course. Teachers in the Logo/PILOT group did not change in their levels of math anxiety after the course, while teachers in the BASIC class became significantly more anxious about mathematics as the course proceeded. Although this study looks like yet another indictment of BASIC, there are some mitigating features. We are not told specifically what the teachers were asked to do with the languages, but from the comments made in the discussion, it seems that BASIC exercises may have resembled textbook mathematical problems, while the PILOT experience involved developing an instructional lesson, an activity which was not mathematically oriented. A valid comparison would have occurred if the BASIC group had focused on the development of a text-oriented lesson, or the Logo/PILOT group had focused on mathematical activities, but it is not clear whether this comparability was achieved.

RESEARCH WINDOWS

Betty Collis

This month's "Research Windows" includes a study on word processing, two studies about gender differences in attitudes toward computers, and two which relate to the evaluation of the impact of specific educational software.

Word Processing: Achievement or Attitude?

Kurth, R. J. (1987). "Using word processing to enhance revision strategies during student writing activities." *Educational Technology*, *27*(1), pp. 13-19.

Twenty-eight secondary school students, enrolled in a voluntary class for interested writers at a university writing center, were randomly assigned to a word processing or non-word processing group for 12 weeks of writing instruction. The instruction focused on revision strategies and was the same for both groups. One group used word processing for their writing during the classes, while the other used only pencil and paper and a photocopy machine to facilitate revision, editing, and sharing of work. No differences were found between the groups in terms of quantity of writing or of revisions, nor were there any differences regarding the types of revisions—either local or global. The only significant differences between the groups appeared on an "attitudes toward writing" questionnaire which was given after the 12 weeks of instruction. The word processing group felt significantly more positive about their ability to write, the instruction they had received, and working with editing groups. Unfortunately, there does not appear to have been a pretreatment attitude assessment, so we do not know if other factors predisposed the word processing group to express these more positive attitudes. One observation is interesting: The word processing group got on task immediately by turning on their computers and getting straight to work, whereas in the non-word processing group, students talked to each other rather than quickly getting down to work. It is encouraging that the lack of typing skill did not seem to disadvantage the word processing students. And it is most interesting that when instruction emphasizing revision strategies was given to both groups, the same patterns of revision occurred among the students regardless of their writing medium.

Gender and Attitudes Toward Computers: I

Swadener, M., & Hannafin, M. (1987). "Gender similarities and differences in sixth graders' attitudes toward computers: An exploratory study." *Educational Technology*, *27*(1), pp. 37-42.

This study is very much limited in value by having only 32 students respond to a 17-item questionnaire. However, one of the findings is sufficiently interesting that other researchers may wish to pursue it with larger student samples. This finding is an "interaction effect," whereby boys with higher achievement levels in mathematics also have higher interest levels toward computers than lower achieving boys, but an opposite tendency occurs for girls. In this sample, lower achieving girls were more positive about computers than the girls who were higher mathematics achievers. If this result can be replicated, it may give us some more insights into the development of the complicated dynamics of self-perception that seem to contribute to secondary school females' lower levels of confidence and participation with computers.

Gender and Attitudes Toward Computers: II

Collis, B., & Ollila, L. (1986). "An examination of sex difference in secondary school students' attitudes toward writing and toward computers." *The Alberta Journal of Educational Research*, *32*(4), pp. 297-306.

Because so many studies document a lower level of participation in and self-expressed confidence about computers for secondary school females compared to their male classmates, it seems useful to see if this relates to a general pattern whereby females express lower self-confidence than males express, or if it more clearly relates specifically to computers. To examine this, grade eight, nine and 12 students (n=1,818) in two British Columbia school districts were asked to respond to a questionnaire including 28 items relating to attitudes about computers or writing—both within and outside of English classes. Females were significantly less positive than their male classmates on every item relating to computers, but were significantly more positive than the males on every item relating to writing. These findings serve to support the use of word processing for secondary school students from an attitudinal perspective: Perhaps females' more positive attitudes about themselves as writers will enhance their perceptions of themselves as computer users when word processing is stressed, and males' positive attitudes about computers may transfer to the writing context with word processing use.

Evaluating Software

Jolicoeur, K., & Berger, D. E. (1986). "Do we really know what makes educational software effective? A call for empirical research on effectiveness." *Educational Technology*, *26*(12), pp. 7-11.

The authors encountered considerable difficulty in trying to locate any published studies pertaining to the educational impact of specific software packages and including some sort of objective measure of learning improvement in the computer group compared to a control group. They found only two studies where this kind of disciplined evaluation had been done. They then examined published reviews of software to see if these reviews could be considered valid sources of information about educational software packages. They found only a weak agreement among reviews of the same software with virtually no agreement at all on ratings of instructional or technical features. They also found a strong tendency for a "halo effect" in evaluations, whereby reviewers who liked one aspect of a program were likely to rate other aspects of the program highly regardless of the actual characteristics. The study is important in that it shows us how little we have accomplished in terms of careful, objective examinations of specific educational software (even though more than 8,000 titles are commercially available), and how we must be cautious in accepting published recommendations about software. This, of course, increases the burden of software purchases for us all, as the difficulties in selecting software are substantial when so many titles are produced but so few are conveniently available for our personal assessment.

Evaluating the Effects of a Specific Program

McCollister, T. S., Burts, D. C., Wright, V. L., & Hildreth, G. J. (1986). "Effects of computer-assisted instruction and teacher-assisted instruction on arithmetic task achievement scores of kindergarten children." *The Journal of Educational Research*, *80*(2), pp. 121-125.

This is the type of study Jolicoeur and Berger attempted to locate but could not find: a controlled comparison of the effects of a particular program. Although this study was not specifically designed as an evaluation of the program "How Many Squares?" by Friedburg and Nickerson, 1982, for Commodore 64 computers), the use of this program was essentially all that varied in the early number experiences of 53 kindergarten children, randomly assigned to a computer or teacher activity group. The children were learning number sequences, one through 20, and had other classroom number experiences besides the computer/noncomputer activities. The researchers found that higher ability children did better in the computer group than in the teacher-activity group, but that lower ability children did better with teacher activities than with the computers. These results may support those found in other studies cited in this article: Children with less representational competence" may find concrete instructional activities more appropriate than computer activities. The authors conclude that the use of the computer in kindergarten classes could free the teacher to have more time with the children needing help while higher ability children are stimulated by programs such as "How Many Squares?"

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1987-1988

RESEARCH WINDOWS

by Betty Collis

This month's "Research Windows" describes five valuable studies: All involve investigating the effectiveness of computer use. Although three relate to mathematics instruction and two to science, their application extends across the curriculum.

Cost-effectiveness of Computer Use

Hawley, D. E., Fletcher, J. D., & Piele, P. K. (1986). *Costs, effects, and utility of microcomputer-assisted instruction.* Eugene, OR: Center for Advanced Technology in Education, University of Oregon.

It is very difficult to determine the cost-effectiveness of computer use in our classrooms and schools—at what point do our ideas for computer use become too expensive to be feasible? To what extent are we willing to spend more, or less, on computer use because of the importance of its outcomes? Hawley, Fletcher and Piele call this the cost-utility of computer use and developed a formula for calculating it in a school district. They applied their analyses to an elementary school where children in grades three and five have been randomly assigned to either traditional mathematics instruction or to traditional instruction augmented by regular use of the *Milliken Math Sequences* programs for the January to May period of a school year. Use of the computer sequences replaced a portion of the regular workshop drill which was done by the students in the noncomputer classes. The computer-using students scored significantly higher on total mathematics achievement than did the noncomputer-using students at the end of this period, although there was no difference between the groups in terms of attitudes to mathematics. The cost per student per day in grade three was 24 cents greater for the computer group than for the other group; the cost per student per day for computer use in grade five was 30 cents greater than the cost of the traditional program. But, if the amount of "grade-placement gain" in mathematics is used as a reference, the cost of producing each "month" of achievement gain was 41 percent less in grade three and 38 percent less in grade five for the computer-using group compared to the regular instructional group. Is this gain worth the money? Using the researchers' formula for cost-utility, which reflects the priorities given to mathematics achievement gain in the school, the computer experience becomes even more attractive from a cost perspective. This well-done study will provide excellent technical support to any educator involved in assessing the impact of computer use and budgeting for its cost. Write to the authors directly at CATE, 1787 Agate Street, University of Oregon, Eugene, OR 97403 for more information.

Evaluation of Computer Use in Chemistry

Reed, J. H., & Judkins, J. (1986). "Evaluation of a holistic CAI system in introductory chemistry." *Journal of Computers in Mathematics and Science Teaching, 6*(1), pp. 21-27.

What are some techniques we can use to evaluate the impact of computer use in the context of the entire instructional system of a course? This study used a number of measures, including student interviews and online attitude surveys. Two hundred thirty-five students in an introductory university-level chemistry course spent two hours a week in a computer lab before they were allowed to proceed to actual laboratory work. Students did drill on the computers and interacted with a simulated lab experience, either to prepare them for an upcoming lab or to let them simulate a procedure which would not be available in the lab. Although Help screens were available during the simulations, a majority of the students did not use them. The students felt the computer was a useful tool in the course, but did not like having their drill graded by the computer. They preferred the actual lab experiences to the simulations, and neither agreed nor disagreed that the simulations improved their performance in the actual labs. The researchers used the results of the evaluation to design improvements both in the simulations and in the ways the computer use was integrated with the rest of the course. This study is a good example of how evaluation can and should accompany the use of computers within an instructional context. The integration of the computer use with the other aspects of instruction needs to be considered: too often evaluations focus more narrowly on just the computer experiences.

Evaluating Science Software

Zohar, A., & Tamir, P. (1986). "A new instrument to assess the inquiry characteristics of science computer software." *The Journal of Computers in Mathematics and Science Teaching, 6*(1), pp. 44-46.

This brief but useful article presents a new type of software evaluation form specifically aimed at identifying the inquiry skills involved in the use of software in the science class. The inventory gives the teacher a checklist that focuses on the nature of the investigation; advantages of the computer investigation over a real lab; the extent to which the software involves the student in planning, predicting, recording, and interpreting; and the focus given to control of variables and hypothesis testing. The authors apply their instrument to different software packages and show how it facilitates a comparison of the packages. The program *Growth Curve of Microorganisms*, for example, receives a higher "inquiry level score" than does the program *Quakes*. This evaluation procedure is very good, both because it attempts to focus on student engagement in process activities as a result of using the software, and because it will probably seem more valuable to the science teacher than would a general evaluation form that reflects more of a drill and practice or tutorial orientation to computer use. The authors can be contacted at the School of Education, Hebrew University, Jerusalem, Israel.

Computer-Videotape Instruction in Mathematics

Henderson, R. W., Landesman, E. M., & Kachuck, I. (1985). "Computer-video instruction in mathematics: Fieldtest of an interactive approach." *Journal for Research in Mathematics Instruction*, *16*(3), pp. 207-224.

Many educators think it will be exciting when computer software used interactively with videodiscs or even videotapes becomes more widely available. This study supports this potential. The authors used a commercially available computer-videotape interface and wrote software that allowed or required the student to stop viewing the videotape on occasion and either ask for examples and clarification or answer questions. The videotapes were designed to motivate the junior-secondary level students for whom the lessons on fractions and prime factors were geared. A particular focus of the materials was to provide examples of people being persistent at mathematics and attributing their performance in mathematics to their efforts rather than to factors beyond their control, such as ability or luck. Female models were used extensively in the tapes. Over 100 students, predominantly in grade nine general mathematics and introduction to algebra courses, were assigned either to a group which used the computer-videotape materials or to a comparison group which did not use the materials. The students who had used the materials did significantly better on mathematics posttests than the students who did not use the materials. In addition, the computer-using students were significantly more likely after the computer experience than the noncomputer students to attribute performance in mathematics to their own effort rather than to causes beyond their control. Interviews with the students indicated they enjoyed the learning experience and would like to participate in additional mathematics lessons with the computer and videotape. These results are especially encouraging, as the majority of these students had "not been making normal progress in mathematics" in their school careers.

Comparing Computer and Flash Card Drill

Fuson, K. C., & Brinko, K. T. (1985). "The comparative effectiveness of microcomputers and flash cards in the drill and practice of basic mathematics facts." *Journal of Research in Mathematics Education*, *16*(3), pp. 225-232.

Is mathematics drill on the computer more effective than mathematics drill with flash cards? This study compared the effects of drill in subtraction and division facts when delivered by a computer procedure or by the use of flash cards when the flash card use paralleled important features of the computer drill. These features were: a limited file of facts individualized according to needs, immediate feedback with the correct answer provided, and immediate feedback on speed. There were no significant differences in achievement for children in the computer and flash card groups over a six-week period of daily practice. This study is especially useful in that it attempts to control many of the variables which often influence a comparison of computer aided instruction with regular instruction. The results suggest both "a limit of and an extension of uses of the microcomputer in mathematics education." The limit is that flash card drill might be just as good as computer drill for basic facts (although this may be a positive finding if it means computers are then freed from drill use and used for more powerful applications). The extension is that the lessons we have learned from investigating what makes mathematics drill effective on a computer can be transferred to the improvement of traditional teaching methods in the classroom. It was not the flash card use in itself which was valuable, but the use in a way that paralleled effective features of microcomputer mathematics drill.

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RESEARCH WINDOWS

Betty Collis

Welcome back, to the third year of "Research Windows." We appreciate your many letters and comments on the column. All of this month's studies were reported at the 1986 and 1987 meetings of The American Educational Research Association. The first two relate to microcomputer-based laboratories in science instruction, the next two describe well-done case studies of young children using Logo and mathematics drill and practice, and the last examines the value of a type of computer-managed instruction for the special education teacher.

Microcomputer-based Laboratories

Linn, M.C. (1986, April). *Learning more—With computers as lab partners.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco. (An article based on this presentation will appear in *Science and Children.*)

Eight eighth grade science classes used computers as "silent lab partners" for one semester. In each class, two students worked at one computer "learning to use the computer as scientists do: to collect data in real time as the experiment progresses, display it, save it, and print it out for further analysis." The students used temperature and light probes and heat pulsars to collect data that were directly displayed on the computer to which the instruments were attached. The teacher involved with these classes "found the MBLs presented no more difficulties than other hands-on activities," were associated with enhanced understanding of scientific concepts, simplified experiments that would have otherwise been demanding, "increased the accuracy of data collection while alleviating the tedium associated with it," and promoted a better awareness of a graph as an expression of a dynamic relationship. The MBL allowed simultaneous association of data collection and display, important as even a short time delay between these can result in students failing "to see the connection between the experiment and the graph." These students using MBLs outperformed 17-year-olds in a standardized test of scientific knowledge and also demonstrated positive attitudes toward experimentation, even to the extent of wanting to repeat experiments several times. Linn also notes that students came to understand the limitations of scientific tools, in that they first tended to trust the output from the computer even when it was based on faulty thermistors, but eventually became "quite proficient at detecting poorly calibrated probes and improper scale choices." With such encouraging results, it seems likely that science teachers everywhere are turning to the use of MBLs in their instruction. However, the next article says that this is not happening and attempts to explain why. (For more information about Dr. Linn's study as well as many others she has done in the area of MBLs, write her at Lawrence Hall of Science, University of California, Berkeley, CA 94720.)

Teachers and MBLs

Berger, C. F. (1986, April). *Misconceptions and thinconceptions of teachers using microcomputer-based laboratories.* Paper presented at the annual meeting of The American Educational Research Association, San Francisco.

Berger and his colleagues are involved in the ongoing exploration of science teachers' concepts and competencies regarding the use of microcomputer-based laboratories (MBLs). Based on their own and other studies, they note that science teachers are not aware of the uses of MBLs and that many even believe computers can only be used in the classroom for drill and practice or tutorial activities. (They note a study of 2,000 secondary school science teachers in Texas where 70 percent of these teachers indicated they did not have enough time to use computers because of the Texas requirement that science teachers spend 40 percent of their time in the laboratory.) Berger notes that it is not only a lack of awareness of the fruitful use of MBLs that limits their use, but that this limited use is also a reflection of more fundamental misconceptions and "thinconceptions" about basic scientific concepts. He defines thinconceptions as concepts learned by teachers from textbooks, not from experimentation, and notes that too often science teachers are more comfortable using printed materials to "find the right answer" than they would be using and believing the results of MBLs. He also notes definite *misconceptions* frequently held by science teachers about fundamental science concepts and observes that many science teachers and science educators are unwilling to expose their misconceptions to others, which may occur if MBLs are used to develop or support concepts. He also suggests that some science teachers are unwilling to use MBLs because, unlike assigning textbook problems, MBL experimentation may not always provide right answers, or even answers at all. His recommendations for the enhancement of MBL use in science instruction focus on professional development involving MBL workshops and user groups. Dr. Berger may be reached at The University of Michigan, School of Education, 610 East University, Ann Arbor, MI 48109.

Logo in Grade Two: Is It Feasible?

Cohen, R. (1987, April). *Implementing Logo in the grade two classroom: Acquisition of basic programming concepts.* Paper presented at the annual meeting of The American Educational Research Association, Washington, DC.

In this thoughtful case study, Cohen routinely visited and observed a second grade classroom over a school year. The class made daily use of a Logo activity center. The 30 children in the class worked in pairs at the center and each pair had an average of two 20- to 30-minute computer sessions per week for seven months. The teacher was fluent with the Logo language and a keen advocate of the Logo discovery learning approach as described by Papert. She provided regular whole-class discussion of Logo commands and syntax and also integrated "Turtle lessons" into physical education, map making, writing, science studies and mathematics. Despite these very good practices of the teacher, many of the children experienced difficulty in trying to gain control over the Logo Turtle and indicated feelings of frustration and helplessness. Cohen notes that many of the children required ongoing instructional support at a personalized level that she was not able to provide with 28 other students in the class. She also notes that the fact that two-digit numbers are needed for FD, BK, RT and LT in order to create noticeable movement was conceptually very difficult for young children who have not mastered the use of larger numbers. Only 11 of the children exhibited "good" choices for distances at the end of the seven months. She notes that the children did not seem developmentally ready to understand the concept of the pivotal movement of the Turtle relative to its own axis regardless of a number of strategies suggested by the teacher. Although all students except for three were able to distinguish left turns from right turns when the Turtle was facing up (and all could tell their own left and right sides), only two students were consistently successful at the end of the seven months in determining the direction of turning when the Turtle was facing down or sideways. Cohen presents many insightful comments that relate the children's experiences and difficulties to developmental theory and discusses a number of modifications to the Logo environment that may make it more appropriate to young children. Anyone interested in Logo and young learners would be well advised to write to Dr. Cohen about her work. Her address is: The Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto, ON M5S 1V6, Canada.

Child-Machine Errors in Drill and Practice

Hativa, N. (1987, April). *Differential effectiveness of computer-based drill and practice in arithmetic.* Paper presented at the annual meeting of The American Educational Research Association, Washington, DC. (A paper based on this research will be published in the *American Educational Research Journal.*)

We know that it is much too simplistic to talk about "the" effect of any instructional strategy as if all students respond in the same way to the strategy. Frequently, research in the effectiveness of computer-aided instruction fails to make this distinction and attempts to summarize the performance of a large set of different types of learners in a single mean score or conclusion. Hativa utilized a case study approach to closely monitor the performance of seven children during regular computer drill experiences over a number of months. She compared the different strategies used by the children, especially in responding to frustration or incorrect answers. In particular, she identified numerous differences distinguishing high-achieving from low-achieving children on the drills; many of these differences relate to things other than arithmetic ability. For example, the better students displayed more competitive spirit, persistence, and initiative in obtaining external help in contrast to the lower-achieving students, who showed less flexibility in their ability to adjust to the CAI environment and who made many more "child-machine" errors (errors that had nothing to do with knowledge of arithmetic). She suggests that the low achievers in her study were not as well able as the high achievers to make the "internal switch from the regular mode of pencil and paper work to the special mode of computer work." Her findings showed the computer practice to be more profitable for better students than for weaker students, a finding inconsistent with many other studies but that is well documented and explained in Hativa's work. Her final point seems obvious, and yet many researchers and teachers and certainly many software advertisers seem to disregard it—Whenever there are students who benefit from a particular computer experience, there are other students with different characteristics who "will face problems working in that particular mode." For more information about this study, contact Dr. Hativa at the School of Education, Tel Aviv University, Tel Aviv 69978, Israel.

CMI and Special Education Monitoring

Fuchs, L. S. (1987, April). *Effects of computer-managed instruction on teachers' implementation of systematic monitoring programs and student achievement.* Paper presented at the annual meeting of The American Educational Research Association, Washington, DC.

Special education teachers must maintain careful monitoring of the achievement of their pupils. In this study, 18 special education teachers were randomly assigned to different methodologies for monitoring and influencing the achievement of two of their mildly handicapped pupils over a 15-week period. Student achievement was compared before and after the treatments, as was teacher fidelity to the instructional procedures they were meant to be implementing. One of the methodology variations involved computer generation of graphs of student progress and computer interpretation of those graphs; the other variation involved the teachers doing this record keeping by hand and required them to interpret their own results. The teachers were also randomly assigned one of two approaches for modification of their own instructional strategies; one of these strategies was less familiar to teachers than the other. The results showed that overall there was no advantage to having the computer generate the displays of student achievement for the teachers: moreover teachers getting computer-generated interpretation in the less familiar instructional modification group were associated with significantly less student achievement or personal fidelity to instructional strategies than were teachers in any other group. The study seems to suggest that when the computer attempts to help the teacher, the overall result may, in fact, not be helpful if the teacher does not have the opportunity to become more personally involved in the data and its interpretation, as "repeated and frequent data manipulation . . . may have facilitated the noncomputer teachers' understanding" of the instructional strategy, whereas removing teachers from the interpretation process may have "thwarted their comprehension." In other words, too much help may not be a good thing, at least for a relatively unfamiliar procedure. For those wishing further information on this or a related series of research studies relating special education and computers, write to Dr. Fuchs at Box 328, Peabody College, Vanderbilt University, Nashville, TN 37203.

RESEARCH WINDOWS

by Betty Collis

This month's "Research Windows" summarizes two studies involving the impact of computers in the science class and three relating to programming, either at the Advanced Placement level or in conjunction with seventh grade geometry.

MBLs and Graph Interpretation

Mokros, J. R., & Tinker, R. F. (1987). "The impact of microcomputer-based labs on children's ability to interpret graphs." *Journal of Research in Science Teaching*, 24(4), pp. 369-383.

Graphs are a central means of communication and "an important tool in enabling students to predict relationships between variables" (p. 370), especially in science; however, "there is ample evidence that students even at the college level . . . can be extremely deficient in their ability to interpret graphs" (p. 370). This report investigated the impact of microcomputer-based labs (MBLs) on the improvement of graph interpretation skills. First, the researchers conducted interviews with 25 seventh and eighth grade students and identified a common tendency to view graphs as pictures rather than symbolic representations. This can cause misinterpretation of many graphs, such as those of velocity ("Draw a graph of a bicyclist's speed over uphill, downhill and level stretches.") and position ("Draw a graph of a person's position on a stage across time."). After five days of MBL activities focusing on graph construction and predictions of what graphs would look like, the children demonstrated that "they had developed solid graph interpretation skills" (p. 374). Following this, 125 seventh and eighth grade students worked with MBL units on visual illusions, heat and temperature, sound, and motion over the course of three months. Some of these units involved the use of temperature probes and an immersion heater interfaced to the computer; others involved a microphone and speaker. The students showed a significant improvement in their abilities to interpret graphic displays after the three months of MBL work. The authors suggest the MBL "appears to be such a powerful vehicle for teaching graphing skills . . . because it uses multiple modalities; it pairs, in real time, events with their symbolic representations; it provides genuine scientific experiences; and it eliminates the drudgery of graph production" (p. 381).

Problem Solving and Simulations

Rivers, R. H., & Vockell, E. (1987). "Computer simulations to stimulate scientific problem solving." *Journal of Research in Science Teaching*, 24(5), pp. 403-415.

Students from beginning biology classes in eight high schools participated in a series of studies involving the use of seven computer simulations as integrated parts of their laboratory experiences. Students were divided into two groups: those who used the simulations and those who studied the equivalent topics in a noncomputerized fashion. In addition, students using the simulations were further divided into two groups: guided and unguided. The guided group interacted with versions of the simulations that included "two to 10 brief paragraphs of strategies to use as they solved the problems presented in the simulation" (p. 407). Students were given pretests and posttests on each topic as well as various tests to assess general problem solving ability. Results showed that on two of the simulations, guided students gained more than the others, while the unguided students gained more than the control students. In addition, a comparison of pretests for each simulation showed the two computer groups significantly outperformed the control students on pretests after the first simulation experience occurred, suggesting that some kind of generalized problem solving improvement was being applied to new simulations by the computer groups. On the tests of general problem solving ability, the guided students did significantly better than the unguided or control students, suggesting that with guidance "students using the computerized simulations were developing generalizable skills which transferred to novel settings" (p. 411). However, when the subscales of the general problem solving tests were considered separately, it was seen that improvement occurred on some scales but not on others, depending on how closely the content of the subscale resembled an activity performed in the simulation. This well-done study is especially encouraging, as it involved students reflecting a variety of socio-economic levels, classes, schools and teachers.

What Are Students Doing in Computer Science Labs?

Pintrich, P. R., Berger, C. F., & Stemmer, P. M. (1987). "Students' programming behavior in a Pascal course." *Journal of Research in Science Teaching*, 24(5), pp. 451-466.

Students in two Advanced Placement computer science courses were observed over several months during the nonlecture portions of their class time in order to see what behaviors characterized their use of this time. The students (20 males and three females) were predominantly seniors and most took other Advanced Placement courses in calculus and physics, so they were highly capable academically. Twenty had computers at home. The students' behaviors were classified into as many of 19 categories that were appropriate at each 10-second interval that they were observed. The largest amount of time was taken up by running their programs, getting help from materials such as the text or worksheets, editing by making minor changes in their programs, or doing trial-and-error debugging. On an average, over two hours of lab time, the students would "run their programs 20 times, make minor changes 24 times, attempt to fix a bug by using a trial-and-error strategy approximately 17 times, or get help from some materials or another person 26 times. Students almost never engaged in any planning behavior, nor did they own write their own code" (p. 457); instead, they copied portions of code supplied to them by their teachers. The students received help from their teachers an average of only three percent of the time they spent in class and were given "no formal opportunities for . . . extended discussions on different design features or different strategies for creating and debugging code" (p. 462). "The students' basic operating strategy was to get on the machine and start programming" rather than plan or consider—a plan of attack similar to that of junior high school programmers. Although these results may be unrepresentative because of the small sample size, we suspect they are not. Unless the teacher requires evidence of planning before any keyboard contact is made, the "rush-to-program" urge will likely be much more compelling to students, even those of high ability, than any urge to engage in higher-level cognitive activities focused on planning and organization.

Instructional Factors Associated with Success in Computer Science

Linn, M. C., Sloan, K. D., & Clancy, M. J. (1987). "Ideal and actual outcomes from precollege Pascal instruction." *Journal of Research in Science Teaching*, *24*(5), pp. 467-490.

In the previous study, we saw that certain behaviors dominate class time activities for at least some computer science students. Can we show that variations in class time activities are associated with success in computer science courses? Fourteen Advanced Placement computer science classes participated in a study of instructional variations. The 242 students in these classes were surveyed as to their programming experience and general intellectual activity, and then all completed the same week-long programming assignment. Based on performance on this assignment, classes were categorized as exemplary (seven classes), enhanced (three classes), and typical (four classes). Students in the three groups did not differ in general ability, although they did differ in prior programming experience, with 80 percent of the exemplary group reporting extensive prior experience compared with 50 percent of the other two groups. Instructional variables also distinguished the groups. Teachers in the exemplary classes spent nearly twice as many hours per week working with their students in the computer lab as did teachers of the students in the other two groups. Also significant is the fact that "60 percent of the students in the exemplary group reported to their teacher a plan for on-line work before logging on to the computer," compared with only 33 percent of the students in the enhanced group and 10 percent of those in the typical group. Finally, teachers of the exemplary classes spent less time in group lectures and more time working with individuals, and provided more constructive feedback than the other teachers. These results are not surprising; they simply reinforce what we already know—that the teacher is critical to the success of computer-related activities, even with highly capable and motivated senior students.

Logo and Geometry Achievement

Frazier, M. (1987). *The effects of Logo on angle estimation skills of 7th graders*. Unpublished Master's thesis, Wichita State University. (For more information, contact Mr. Frazier at 1106 Cottonwood Road, Derby, KS 67037.)

The effects of Logo on achievement and attitudes comprise one of the most active areas of computer-related research. This study makes a good contribution to that battery of results. Four intact seventh grade classes representing average ability students in two schools participated in this study. Two of the classes participated in a traditional seventh grade mathematics curriculum, which included a specific unit on geometry. The other two classes substituted one class period per week of their mathematics time on Logo activities in place of any direct instruction in geometry. Students in the Logo groups met in a classroom with 12 computers and worked with a partner during all Logo activities. All students were given a 60-item test on various applications of angle estimation skills at the start of the school year and again in May, immediately after the control groups finished their geometry instruction. The control group classes did somewhat better on the pretest than the Logo group students (47.9 percent correct compared with 41 percent); however, this difference was reversed in the end-of-year testing, when the Logo group improved its overall proportion correct by 22 percent while the geometry instruction group improved by 13 percent. Significant differences between the Logo and regular instruction groups were found in all six subtests of the posttest: recognizing angles of various sizes, estimating angles of various sizes, constructing angles, recognizing polygon angles, and estimating exterior and interior angles of polygons. Unfortunately, we are not told whether the control group students also emphasized angle estimation in their "traditional geometry instruction." It is also unfortunate that students were not tested on a wider range of geometry competencies in addition to angle recognition, as it is clear that these particular competencies relate directly to Logo activities while only representing a relatively small component of the overall geometry curriculum. However, the fact that significant achievement on this component can occur without any formal geometry unit is useful support for those who wish to demonstrate the relevance of Logo activities to existing curriculum objectives in mathematics.

RESEARCH WINDOWS

Betty Collis

This month's "Research Windows" involves an interesting variety of studies. Two involve fourth graders, using computers either for drill or for Logo; one summarizes use of computers with disadvantaged and limited English proficiency students; one summarizes a series of studies and observations about the difficulties associated with successful implementation of computer use in schools; and the last looks at gender differences in computer-related attitudes, this time at the university level.

"The Hidden Curriculum"

Roessler, M. J. (1987). *Fourth graders and computers: A case study.* Unpublished doctoral dissertation, Michigan State University, Lansing, Mich.

Roessler employed an ethnographic approach to his investigation of the weekly use of a computer lab primarily for mathematics and language drill by the 26 members of a fourth grade class over a six-month period. His observations are well expressed and carefully substantiated. He notes that the children avoided "anthropomorphizing" the computers; "they rarely speculated about how they worked or what they had inside of them" (p. 130). Also, students did not concern themselves with the meanings of specific phrases, particularly error messages, but instead used a trial-and-error approach to proceed with the program rather than finding out what the unknown phrases meant. The students accepted the rules associated with the computer drill programs, particularly those involved with input regulations, but also "seized control for themselves" (p. 138) by experimenting with the machines in a variety of ways. The students "accepted, and took pleasure in, the computers' evaluations of their work and . . . internalized its standards of their performance" (p. 144).

Most interesting in Roessler's study is his identification of a "hidden curriculum" of computer use and how it contributed to the children's "being socialized into the information age" (p. 169). The main elements of this hidden curriculum are: 1) computers encourage quantification of results and performance; 2) using computers entails a loss of privacy, as students' "peer at and discuss each other's written work," (p. 179), a sometimes awkward or embarrassing situation when performance was summarized; 3) work generated on a computer can be evanescent, resulting sometimes in a "pride of ownership that went unfulfilled" (p. 184); and 4) access to computers is a privilege, where certain students have more opportunities for computer access than do others. Roessler concludes with suggestions for enhancing the value of students' computer experiences, in particular by including debriefing sessions after computer use to "take advantage of the serendipitous," "drag the hidden curriculum out of hiding," and "draw comparisons between the programs and their classroom lessons" (p. 202). For more information about this thoughtful investigation, contact Dr. Roessler at 716 Tanbark, Dimondale, MI 48821.

Categories of Logo Learning

Mayer, R. E., & Fay, A. L. (1987). "A chain of cognitive changes with learning to program in Logo." To appear in the *Journal of Educational Psychology, 79*(3).

Mayer and Fay investigated the question "What do students learn when they are given a series of experiences in using simple Logo commands to write programs?" by studying three kinds of changes that occurred when 30 fourth grade students participated in three sessions of Logo learning. The children worked only with the primitives LT, RT, FD and BK, and with turn orientations of 0, 90, 180 and 270 degrees. The first kind of change that was investigated was that in the child's knowledge of the specific features of the Logo language. This kind of change was supported by significant improvement on a test administered three times on each type of Logo command involving each initial Logo orientation. The commands differed in difficulty for the children, however, with FD easier to interpret than BK and BK interpreted more successfully than RT and LT. The second kind of change investigated in the study was change in the child's thinking within the domains of programming, in particular, with regard to "egocentric bugs" (thinking "turn right" means to turn to the right side of the screen rather than the Turtle's right) and "interpretation bugs" (thinking "turn right" means to turn and then keep moving). The children significantly decreased their misconceptions in these two categories over the three Logo sessions. Finally, the study investigated changes in the children's thinking in domains beyond programming; in this case, performance on a map reading test interpreted as a measure of spatial problem solving. Students who lost their egocentric bugs from Day 1 to Day 3, or who never had them, showed significant gains in the map test, whereas students who retained egocentric bugs did not show map test improvement.

This study is valuable for a number of reasons. It is well designed, it shows that substantial learning can occur after only a brief exposure to Logo, it clarifies a chain of learning, and it documents specific misconceptions related to egocentricity and interpretation. Most valuable, however, is the evidence "that under appropriate conditions, learning to program can modestly influence children's thinking in areas similar to those involved in programming," (p. 26) but that this influence related "not to Logo instruction per se . . . but rather Logo instruction coupled with a learner who is 'ready' to benefit from Logo" (p. 21). For more information, contact the authors at the Department of Psychology, University of California, Santa Barbara, CA 93106.

Disadvantaged and Limited English Proficient

Andelin, J. (1987). *Trends and status of computers in schools: Use in Chapter 1 programs and use with limited English proficient students.* Staff paper, Science, Education, and Transportation Program. Office of Technology Assessment, U. S. Congress, Washington, D.C.

In the United States, a federally funded program titled Chapter 1 provides compensatory educational and related services to approximately 4.8 million educationally disadvantaged students who attend schools in low-income areas. The state coordinators of the Chapter 1 programs were surveyed regarding use of computers with the students they serve. This report summarizes the responses to the survey, and among its findings are the following: Approximately 72 percent of the Chapter 1 teachers in elementary schools and 56 percent of the Chapter 1 teachers in secondary schools use computers; in the poorest elementary schools the percentage of Chapter 1 teachers using computers is lower than in other schools; approximately 60 percent of the Chapter 1 teachers who teach mathematics and language arts use computers, but only 22 percent of the Chapter 1 teachers who exclusively teach English as a second language are computer users; all states report Chapter 1 computers are used for drill and practice, and 35 states report using computers for problem solving; and teachers generally believe that "computer use raises students' enthusiasm for subjects in which the computer is used" (p. 51). However, only 13 state coordinators indicated computers were being used with "limited English proficient" (LEP) Chapter 1 students.

LEP students as a group (both Chapter 1 and non-Chapter 1), are "the fastest growing segment of school-age population in the United States today" (p. 75). The use of computers with these students, as supported by federal funding through the Title VII program, was also summarized in this study. The results show that "the percentage of teachers who use computers in instructing their LEP students is consistently less than one-half the percentage of teachers who use computers in teaching other students," (p. 81) despite the benefits that CAI and computer use for writing practice can supply to LEP students (pp. 84-89). Some of these benefits are described in the study in terms of specific reports from various local projects. However, "the line to use school computers is still a long one, and the LEP student is put at the back of the line. His teachers see that the materials are almost always written in English, and assume the non-English speaking student will not be able to profit from them" (p. 81).

This 129-page report contains extensive survey data including many tables and figures relating to general computer use in the United States. Those desiring current data on trends and practices in the United States should contact the Office of Technology Assessment directly about this study.

Implementing Computer Use

Fullan, M. G., Miles, M. G., & Anderson, S. E. (1987). *Strategies for implementing microcomputers in schools: The Ontario case.* Ministry of Education, Toronto, Ontario.

In this 151-page study Fullan and his colleagues summarize interview data, 11 field reports, and 38 other documents relating to the implementation of "new educational technologies" (NETs) in Ontario schools since 1982. The "crucial messages" they synthesize from these data are that "current visions of the potential for NETs in education vastly underestimate how difficult it will be for teachers to implement the changes NETs will require in practices, materials, beliefs, and skills" (p. 141) despite having access to hardware, software and inservice experience; and that there is a critical need for the identification and development of effective teaching practices for the actual pedagogical use of software in the classroom. The report considers in detail 10 factors that influence computer implementation in classroom instruction and concludes that modeling or otherwise demonstrating actual strategies for the use of specific software packages in different classroom settings is especially needed. Initial experience with a videotape providing this sort of modeling has proven to be well received by Ontario teachers (pp. 68, 76). The report concludes with a series of 30 suggestions for the "stimulation of quality implementation" (p. 106) of computers in schools. These suggestions include recommendations for the central educational authority in a region as well as recommendations at the school level. The recommendations are sound and valuable, and are not specific to the Ontario situation. This report is highly recommended for anyone who is involved in implementation, evaluation, and teacher training from a policy or coordination perspective. In addition to the summary of factors influencing implementation of computer use in schools, the report contains frequent discussions of specific findings from fieldtests in Ontario that are also very helpful in increasing our understanding of the dynamics surrounding computer implementation in the actual classroom setting. For more information about this report, contact Mr. Lorne Smith, Director, Computers in Education Centre, Ministry of Education, Queen's Park, 24th Floor Mowat Block, Toronto, ON. M7A 1L2.

"We Can, But I Can't" Revisited

Horton, N. J. (1987). *Sex differences in attitudes toward computers.* Unpublished manuscript, Department of Psychology, Harvard-Radcliffe Colleges, Cambridge, Mass.

Each time a review of a study relating to gender differences in computer use or attitude appears in "Research Windows," a number of requests for more information about work in this area result. Horton's study used my own instrument for measuring attitudes toward computers (see *The Computing Teacher*, April, 1984, pp. 33-36), and focused particularly on the "We can, but I can't" paradox I identified in the secondary school females in my sample, who believed that "women in general" had as much ability as men with respect to computer use, but that they, as individuals, would not be comfortable or particularly competent in computer use. Horton found the same paradox to be exhibited by first-year females at Harvard and Radcliffe. However, females who indicated a technical area (math, science, engineering, computer science) as their major were significantly less likely to display the paradox than were females who were not majoring in technical areas. This is encouraging to the extent that it suggests the paradox diminishes with apparent interest and experience; however, it is discouraging in that it shows the paradox still to be functioning in capable adult women attending universities with high academic expectations. It seems that the "We can, but I can't" feeling about computer use, illogical as it may be, can still be part of the psychological dynamics of bright and successful females. For more information, contact Mr. Horton at P.O. Box 832, Cambridge, MA 02238.

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we first summarize three studies—one focusing on the attempt to provide appropriate diagnostic feedback for common student errors, a second examining the impact of a year's experience with word processing on the writing skills of second grade children, and a third investigating the relative benefits of working collaboratively and individually at a tutorial—each of which demonstrates the difficulties in trying to establish the effectiveness of computer intervention. We also summarize two studies which attempt to identify predictors of success in first-year university computer science. Both find the benefits of taking high school computer science to be limited.

Targeted Remediation or Reteaching?

Martinak, R., Schneider, B. R., & Sleeman, D. (1987, April). *A Comparative Analysis of Approaches for Correcting Algebra Errors via an Intelligent Tutoring System.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

Many students make order-of-precedence errors in solving algebra problems. Sleeman calls these types of consistent errors "mal-rules." Is it more effective to provide targeted remediation—feedback about how to correct a specific mal-rule—or to reteach the correct strategy without focusing on the student's misconception? Martinak and her colleagues developed an intelligent tutoring system capable of diagnosing a number of algebra errors. Thirty-nine high-achievement and low-achievement ninth and 10th grade students were randomly assigned to three different versions of the tutoring system: one with targeted feedback, one with reteaching, and one with only evaluative comments (correct or incorrect) after each of 17 problems. Pretests and posttests involving similar problems were also administered before and after the use of the tutoring system.

For high-achievement students, type of response proved to be immaterial, as most of these students scored near mastery. For low-achievement students, "evaluation comments only" was significantly less effective than either of the other types of feedback; however, no differences were found between the targeted and reteaching groups. The authors speculate that this lack of difference may reflect the difficulty in anticipating students' mal-rules in order to provide appropriate targeted remediation; despite the considerable work expended on this by this research team, the program was only able to anticipate 30 percent of the students' errors. This study reaffirms that until the "expert diagnostic systems" that experienced teachers carry with them can be better articulated, the ability of software to provide useful individual remediation will continue to be limited.

Grade Two and Word Processing

Porter, R. (1987). *A Report on the Project "Word Processing, the Writing Process, and Revision Strategies in Young Children."* Unpublished manuscript, Macquarie University, New South Wales, Australia.

This carefully done study describes the use of word processing by 26 children throughout their second grade year. These children had already been regular users of word processors throughout first grade, and in addition had the support of a research assistant who worked with them at a classroom computer for three days a week throughout the second grade. The total amount of time spent at the computer for individual children ranged from 4.5 hours to 20.5 hours. A control group was compared to the computer group with respect to reading and spelling. Despite the extensive use of word processing in the presence of a supportive "second teacher," no differences were found at either the beginning or the end of second grade for these two groups. Members of the computer group, however, indicated they made more changes in meaning and structure in their writing by the end of the year than did the control group (data obtained from interviews with the children); however, the computer group's teacher emphasized revision to a greater degree than the control group's teacher. The majority of the computer group children indicated it was easier for them to make changes with a word processor than with a pencil and that they preferred writing at the computer compared to writing with pencil and paper.

This study is yet another example of the difficulty in designing a realistic investigation of the benefits of word processing compared to non word-processed writing on the development of language skills; confounding variables are many and likely to influence any conclusions. The researcher acknowledges this and emphasizes the critical interrelationship between the teacher's instructional strategies, the classroom writing environment, the level of development of the young child's literacy skills, and his or her use of word processing. Despite its inability to provide the sort of justification for word processing that many people continue to look for, this study provides a contribution to the word processing literature through its case studies, its careful examination of individual children's keyboarding strategies, and its consideration of nine "revision profiles" that may help to clarify measurement of growth in revision skills in young children. Also, the study notes the importance of drawing in the early stages of writing. For more information on this 64-page report, contact Dr. Porter at the School of Education, Macquarie University, New South Wales 2109, Australia.

Collaboration or Individual Activity?

Carrier, C. A., & Sales, G. C. (1987). "Pair Versus Individual Work on the Acquisition of Concepts in a Computer-based Instructional Lesson." *Journal of Computer-based Instruction, 14*(1), pp. 11-17.

Is it better to pair students at the computer or for each student to work independently?

As with any question of this sort in education, there is no simple answer other than "it depends." In this study, 36 university students were randomly assigned to be members of 12 pairs or to work individually at a computer tutorial which offered students their choice of four types of feedback after each question. The feedback types were: no feedback, knowledge of results, knowledge of results and correct answer, and elaborative feedback. Pretests, posttests and retention tests were given to each student individually, the amount of time spent on each frame was recorded automatically by the software, and students working in pairs were audiotaped as they worked at their computers. There was no difference in overall achievement on either the posttest or retention test for students who had worked individually or in pairs. However, students working in pairs spent significantly more time on practice items and on inspecting the menu identifying the feedback types available than did the students who worked as individuals. Also, students working in pairs were significantly more likely to choose the elaborative feedback option than were those working individually, perhaps because the paired students often disagreed with each other on responses and were more interested in turning to the computer for resolution. There was considerable variation in what the paired students talked about; approximately 25 percent of their exchanges were "off-task," reducing "the efficiency of learning time." These "superficial exchanges" lead the researchers to conclude that "we need to learn more about what characteristics to look for in pairing students so that the most productive working relationships will be fostered" (p. 16).

High School and University Computer Science: I

Greer, J. (1986). "High School Experience and University Achievement in Computer Science." *AEDS Journal, 19*(2/3), pp. 216-225.

This study and the next both investigated factors that may be associated with performance in introductory university computer science courses.

Greer's study focused on 56 students who had completed high school computer science courses and 61 of their university first-year computer science classmates who had not taken any high school computer science even though such courses were available to them. Although there were no significant differences between these groups of students on a measure of intellectual ability or on a computer science aptitude test, 54 percent of the inexperienced group withdrew from the university course compared to only 14 percent of those with more than one semester of high school computer science. However, among the students who persisted there was no advantage associated with having taken high school computer science or with having more or less emphasis on structured programming as part of the high school experience. Greer concludes that "high school computer science experience . . . is not related to examination achievement in university computer science . . . [nor will] higher grades in university computer science result from high school computer science experience" (p. 224). For more information, contact Mr. Greer at the Department of Mathematics/Science Curriculum, College of Education, The University of Texas at Austin, Austin, TX 78712.

High School and University Computer Science: II

Connors, J. M. (1987). *Persistence in Computer Science by First-year Students at the University of Victoria.* Unpublished master's thesis, University of Victoria, Victoria, British Columbia.

Connors was also interested in the impact of high school computer science experiences on persistence in university computer science; her particular focus was on gender differences in this persistence. She surveyed 269 students (189 males and 80 females) at the University of Victoria in September 1986 who enrolled in the first computer science course and indicated they expected to continue on to the second course in January 1987.

Fifty-one percent of the males and 45 percent of the females who in September intended to take the second course actually did persist in taking it in January. Connors developed models to predict persistence and found that different patterns of influences seemed to describe males' and females' likelihood of persistence. Persistence for females was associated significantly more with affective considerations, such as feeling comfortable in the lab or lecture, than it was for males. In addition, and most strikingly, having taken a high school computer science course gave the students very little benefit in either achievement or persistence in university computer science, and in fact had an overall "suppressor" or negative impact on persistence in university computer science when considered in the context of other relevant background variables.

Ms. Connors' study makes careful use of path analysis to test the fit of her prediction models and provides an excellent example of the use of this procedure to clarify patterns of association in a set of intercorrelated predictor variables. For more information, contact Ms. Connors at the College of New Caledonia, Prince George, British Columbia.

RESEARCH WINDOWS

by Betty Collis

This month's Research Windows reports five language-related studies. For those interested in research in this area, I recommend an excellent summary of research that identifies and abstracts hundreds of studies relating to the impact of computers in language arts: Blanchard, J. S., Mason, G. E., & Daniel, D. (1987). Computer Applications in Reading (Third edition). *Newark, DE: International Reading Association.*

Speech Synthesizers and Writing

Borgh, K., & Dickson, W. P. (1986, April). *The Effects on Children's Writing of Adding Speech Synthesis to a Word Processor.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

The *Talking Screen Textwriter* is a word processor that includes a speech synthesizer and allows the writer to choose to have letters, words, sentences, or longer sections of text spoken aloud. The program has been used with children who have communication disorders, but the use of spoken feedback during writing may facilitate the writing process for regular writers, both for motivational reasons and because "hearing the computer 'speak' their written words may encourage children to take an audience's perspective on their work" (p. 3). In order to examine the impact of this spoken feedback on writing, 48 students from two second grade and two fifth grade classrooms wrote two stories under a spoken feedback condition and two stories using the same word processor but without spoken feedback. The order in which the children experienced the writing conditions was randomly assigned as were picture stimuli which were used as the story starters for each writing episode. There were no significant differences in length of written composition or quality of writing for stories written with spoken feedback compared to stories written without spoken feedback. There were also no significant differences in the quantity or type of editing that occurred when students had the program read or reread the entire text. However, there was significantly more sentence-level editing when students received spoken feedback after writing an individual sentence. Overall, when spoken feedback was compared to no spoken feedback and when editing categories were combined. "Regardless of grade level, school, or sex, children did between three and seven times more editing under the spoken feedback condition" (p. 13). Editing occurred both for "lower-level," grammatical errors and for "higher-level," content-related errors. When interviewed, 40 of the 48 children indicated that they enjoyed writing better when the computer "talked" than when it didn't; they did not, however, indicate they were thinking more about making changes for a specific audience when they heard the spoken feedback than they did when they wrote silently.

These results are encouraging, especially as the type of voice synthesizer used in this study can be obtained for only about $200. The results suggest we look more carefully at utilizing the computer's capabilities that allow children to experiment with the interrelated roles of reader, writer, and listener. For more information, write to the authors at Child and Family Services, University of Wisconsin, Madison, WI 53706. Also, see the chapter on Speech Technology and Reading in the book by Blanchard, Mason, and Daniels mentioned in the introduction to this column.

WTR and Grade 1 Writing

Ollila, K. (1987). *A Comparison of the Effectiveness of the Computer-Based Writing to Read Program with a More Traditional Language Arts Program with Respect to Their Impact on the Development of Writing Skills at the Grade 1 Level.* Unpublished master's thesis, University of Minnesota.

Another program that uses a speech synthesizer as part of the language arts experience is *Writing to Read* (WTR). In this program, a phonetics approach to initial language learning is used in order to give children a way to write whatever they can say. The speech synthesizer is used in the context of phonics drill and practice rather than in the context of writing. It is not possible to comment directly on the impact of the speech synthesizer or even of the computer component in WTR, as no research design has yet tried to isolate those features from the effect of the overall WTR experience involving a multimedia station approach, an emphasis on daily writing, the presence of classroom aides, and the general Hawthorne effect of this well-publicized system in a school. Ollila was able to control some variables in her study comparing the writing achievement of non-WTR children with WTR children. She and her colleague, both first grade teachers at the same school for 13 years, have been collecting standardized language readiness data at the beginning of Grade 1 and reading and writing achievement data later in Grade 1 from their classes for many of these years. In this study, children in the 1983-84 school year, prior to the teachers' exposure to WTR, were compared to children in the 1985-86 school year, during which WTR was used. There were no significant differences for the non-WTR and WTR children in their September scores on the language readiness tests, suggesting an essential equivalency of the children in those two years. This equivalency was supported by the teachers' own assessment of the children based on many years of familiarity with the community in which the school is located. Writing samples were also collected in May of each of these school years, using identical procedures, and scored using both syntactic and holistic measures. Ollila's use of both types of measures distinguishes her work from that of the Educational Testing Service (ETS) evaluation of WTR, which used only a holistic rating. Unlike the ETS study, Ollila found no significant differences between the holistic ratings of the non-WTR and WTR children's May writing samples. However, she did find significant differences between the groups on six of eight syntactic measures of amount and complexity of sentence structure. She found no gender differences in either condition on any of the writing variables. She concludes that WTR is supported as "an effective tool for teachers to use in improving the quality and quantity of Grade 1 writing" (p. 134). For more information, contact Mrs. Ollila at 1712 Algoa Place, Victoria, B.C., V8S 5J6.

WTR: Evaluation of the Overall System

Collis, B., Ollila, L., & Muir, W. (1987). *Interim Report on the Victoria Installation of Writing to Read.* Publication Number 11. University of Victoria-IBM Canada Software Engineering/Education Cooperative Project, Victoria, B.C.

Collis (myself), L. Ollila, and Muir evaluated the same WTR program implementation described by K. Ollila in her study. In addition, I and my colleagues included a second school where WTR materials were used (but not in the systematic way prescribed by its authors and used by K. Ollila and her fellow teacher), and a third school which acted as a control. This evaluation study considered the broader context of the WTR experience, including not only achievement variables but also attitudinal variables expressing the perspectives of students, parents, teachers, administrators, and academic specialists. In addition, an evaluation of the component parts of the system was carried out.

As with the ETS evaluation, we found no significant difference between non-WTR and WTR Grade 1 groups on reading achievement; as with ETS and K. Ollila, we found significant differences in terms of writing achievement favoring the WTR children. In terms of attitudes, parents and students maintained continual enthusiasm for the program and parents indicated they felt the computer component (consisting only of drill) to be the most valuable aspect of the program. Teachers did not agree and preferred the writing stations (in this implementation of WTR, typewriters were used instead of word processors; newer versions of the system use word processors for writing). Teachers criticized the listening station, the synthesized speech accompanying the computer drill, and the "make words" component of the system. In each case, criticisms related to awkwardness of usage. More fundamentally, there were significant criticisms made of the WTR software for being repetitious, not allowing for individual differences among students, and focusing on words chosen for phonemic reasons (such as snake, vase, yard, smoke, turtle, oil, and uniform) rather than for their relevance to the children. Teachers perceived the rigid way in which student use of the system is meant to be managed as a negative feature of the system and quickly incorporated their own modifications; however, all endorsed the emphasis on daily writing. Despite daily, structured use of computers in a language context, children in the WTR classrooms finished the year perceiving computers as being "something for boys"; a perception that was also expressed in the other grade 1 classrooms involved in this study. For more information, contact me at the address at the end of this column.

Deaf Adolescents and Sentence Construction

Ward, R., Lindley, P., Rostro, A., Sewell, D., & Cubie, R. (1985). Computer-Assisted Learning and Deaf Children's Language: Using the Language and Thought Software in a Hearing-Impaired Unit. *Journal of the British Association of Teachers of the Deaf, 9*(3), pp. 61-66.

Six profoundly deaf teenagers with a mean reading age of seven years used specially developed "language and thought" software that allows them to hold written dialogues with the computer about graphics displayed on the monitor. Thirteen word and phrase units are available and 62 "acceptable" sentences can be constructed. The software allows either the computer or the user to initiate questions ("Where is the green box?") or commands ("Put the triangle in the red box."). The subjects used the software for 12 weeks. Before and after using the program, they did activities similar to those used in the program, but using real objects and communicating with a researcher by pointing, word by word, to vocabulary cards. Substantial improvement occurred in the students' communication skills after using the computer program. For example, there were syntax errors in 45 percent of the phrases formed by the students before the treatment, compared with only 25 percent after the treatment, and the number of error types was reduced from 27 to 16. Also, students became more efficient in their use of language, requiring only a total of 12 extra (unnecessary) sentences to communicate their intentions after the computer treatment compared with 28 before. There was also a qualitative improvement in the types of sentences produced by the students after using the software.

This study is an example of the work being done in England by special education specialists exploring the potential of computers with exceptional students. (D. Sewell, one of these researchers, is a member of the ICCE International Committee.) The research and development work being done is of high quality and should be of interest to all special educators. For more information, contact R. Ward at Department of Computing, Trent Polytechnic, Nottingham, UK, NG1 4BU, or D. Sewell at Department of Psychology, Hull University, Hull, UK, HU6 7RX.

Attitudes Toward Writing with Different Tools

Baer, V. E. H. (1987). *Computers as Composition Tools: A Case Study of Student Attitudes.* Paper submitted for publication.

A number of studies have compared the responses of students to writing with word processors with their responses to writing with traditional tools. Baer's study contributes to this collection because of its carefully done methodology, its large sample (58 grade 7 students interviewed and observed over a four-month period), and the identification of contextual variables that affect students' attitudes toward writing and prevent straightforward statements about the impact of word processing on these attitudes. Baer notes the influence of three contextual variables in particular: the content of the writing assignment, including the appeal of the topic and how much involvement students have in noncomposing activities; the place in which writing activities occur, including the physical arrangements of the classroom or lab and how much of the teacher's time is spent on maintaining the classroom environment; and the method used for writing, including characteristics of the word processor itself and the quality of printed output obtained. Baer observes that writing content seemed more important to the enjoyment of writing in the classroom whereas "in the computer lab, level of participation was more uniform and students worked with concentration most of the time" regardless of the content of the writing assignment. She also noticed more "stalling" behaviors in the regular classroom and more on-task behavior in the word processing environment. "The computer lab's physical arrangement seemed to foster a quiet atmosphere, so teachers could act more like content specialists" (p. 10) and spend less of their time on managing student behavior than they did during writing in the regular classroom using traditional tools. Write to Dr. Baer, Director of the Learning Resources Center, Box 3 CUR, at the College of Education, New Mexico State University, Las Cruces, NM 88003.

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we look at a variety of studies: three relating to microcomputer-based laboratory experiences; one investigating a model for student and teacher evaluation of software: one on technology-related school preparation for non computer science students; and an evaluation report summarizing characteristics of effective teacher training and inservice courses.

MBLs and Uncritical Acceptance of Computer-Generated Graphs

Nachmias, R., & Linn, M.C. (1987). "Evaluations of Science Laboratory Data: The Role of Computer-Presented Information." *Journal of Research in Science Teaching, 24*(5), 491-506.

In the context of being a student of science, there is a fundamental difference between seeing oneself as an observer of phenomena and being a participant in the process of determining the nature of the natural world. The different perspectives students can bring to the interpretation of graphic data obtained from laboratory experiments is a good example of this. Nachmias and Linn examined eighth grade students' propensities to accept incorrect graphs generated by computer collected data. Students typically failed to criticize scaling decisions that allowed only a portion of the graph to appear on the monitor, or graphs resulting from improper probe setup, calibration, or sensitivity. In addition, students tended to accept a computer generated graph as always valid rather than consider the likelihood of experimental variation. In this context, 249 students in eight different (Grade 8 classes used the Computer as Lab Partner Curriculum (based on activities and software from Robert Tinker's Technical Education Research Centers) in which they carried out 54 temperature, heat, and energy activities over an 18-week period. The activities involved the use of a classroom computer as a tool for the collection and graphic display of data. At the end of these experiences, the students showed significant decreases in their tendencies to accept invalid data. When "enhanced instruction" occurred, student ability to recognize the role of graph scaling and experimental variation improved even more. The authors conclude by emphasizing "the importance of instruction emphasizing critical evaluation of scientific data" and note the MBL (microcomputer-based laboratory) "provides an opportunity to raise these issues in science classes." This is an excellent study, as we have come to expect from Linn and her colleagues. I recommend that people looking for examples of good, practical research in the area of computers in education contact Dr. Linn at the Lawrence Hall of Science, University of California, Berkeley, CA 94720, about her extensive research activities.

More Variables in the Effectiveness of MBLs

Brassell, H. (1987, April). *The Role of Microcomputer-Based Laboratories in Learning to Make Graphs of Distance and Velocity.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. *Sex Differences Related to Graphing Skills in Microcomputer-Based Labs.* Paper presented at the annual meeting of the National Association of Research in Science Teaching, Washington, DC.

In these two related studies, physics students in a variety of rural secondary schools participated in either paper-and-pencil or computer activities focused on distance and velocity. These activities occurred in a single class period. (It is not clear from the articles if both studies are based on the same set of data or if one is a replication of the environment described in the other.) The single computer experience proved helpful for the female students in the samples in items relative to distance, while the male students showed a significant improvement in velocity items. However, the females "rated the MBL activity as significantly more difficult and confusing, and said they enjoyed the activity less than did the males" (p. 3). Brassell concluded that females' graphing skills were more "constrained by lack of ability" in graph generation strategies "whereas males are more likely to be constrained by lack of interest" (p. 4). In the companion study, Brassell observed students to benefit more from immediate graphic displays of pertinent data rather than delayed displays, as "students just waited passively" for the display to eventually occur rather than using constructive "maintenance and rehearsal techniques" (p. 4) as they waited. In conjunction with Linn's more extensive studies, these reports by Brassell add to our understanding of the complexity of predicting the impact of a computer-based experience in the classroom context. For more information, write to Brassell at P.O. Box 46, Alapaha, GA 31622.

Students as Software Evaluators

Callison, D., & Haycock, G. (1987). *A Methodology for Student Evaluation of Educational Microcomputer Software.* Unpublished manuscript, Indiana University.

Over a three-year period, Callison and Haycock coordinated the software evaluation activities of 291 teachers and 2,308 students in grades 3 through 12 in nine Indiana school corporations. In total, 135 educational programs were evaluated. This report suggests a methodology to use to involve students in software evaluation and provides an efficient system to document the students' responses. The study also offers many interesting insights into differences and similarities in teachers' and students' evaluations of the same software packages. Some interesting observations include: Student evaluations focused more on characteristics of the software itself, such as difficulty or "memorable graphics," rather than on concepts or new ideas learned through the software; there were no significant differences between evaluations completed by students with little or no prior experience with educational software and those completed by students having experience with 10 or more programs; there was only a weak correlation between the programs rated highly by students and those rated highly by teachers, as simulations were rated more highly by students, but tutorials and—surprisingly—games were rated more highly by teachers; teachers and students agreed more on programs both groups rated as poor than they did on programs rated as good; boys favored competitive aspects in programs more than girls did; and "team or cooperative learning approaches which involved two or three students working together tended to enhance the learning experience more in the use of problem solving programs than when a student faced such programs alone" (p. 7). I strongly recommend this report for its efficient and effective approach to software evaluation. For information, write to Dr. Callison at the School of Library and Information Science, Indiana University, Bloomington, IN 47405.

Computer Competencies in Liberal Arts Training

Kurshan, B. (1986, May). *Career Paths of Women Graduating with Technological Courses.* Paper presented at the World Congress of Education and Technology, Vancouver, BC, Canada.

Kurshan examined the relationship between the traditional liberal arts curriculum and the demands for technology-related competencies in many vocational areas where graduates end up finding employment. Although her study focused on the importance of computer-related courses to subsequent employment among women graduating from a small liberal arts college, her conclusions can be equally relevant for secondary school counselors. More than half of the seniors in Kurshan's study who had taken two or more computer-related courses cited the experience they received in these courses as "the key to obtaining their present (employment) positions as well as providing the potential for growth within the company" (p. 2). The students felt strongly that a course called Microcomputers in the Business World provided them with experiences pertinent to the professional business environment. Graduates of the college "felt that database processing, telecommunications, and information systems should be added to the liberal arts curriculum" because of the "changing job market for graduates of liberal arts institutions (where) employers are implicitly seeking graduates with computer skills" (p. 4). Kurshan also concludes that career counseling should clarify for students the desirable or necessary "unwritten" computer skills in job descriptions. This suggestion seems especially pertinent for high school counselors, particularly those working with female students who we know systematically distance themselves from many vocational options through premature self-limitations in secondary school. Write to Dr. Kurshan about this study at Janus Learning Center, 4370 Starkey Road, Roanoke, VA 24014.

Characteristics of Effective Teacher Inservice

Stecher, B.M., & Solorzano, R. (1987). *Characteristics of Effective Computer Inservice Programs.* Report prepared for the Educational Testing Service, 2 North Lake Ave., Suite 510, Pasadena, CA 91101.

This is an excellent evaluation report on components that contribute to effective computer inservice programs. From over 50 nominations throughout the United States, the evaluators selected a sample of eight school districts indicated as having particularly effective models of inservice computer education programs. (An interesting aside here is that the majority of the 30 experts who were asked to provide these nominations had little knowledge of any inservice practices outside their immediate local areas, and there was very little overlap in nominations received. "It appeared that no one possessed comprehensive information about inservice practices in the field of educational computing on a nationwide basis" [p. 8]). The conclusions of this study should not be surprising, but bear repeating despite their apparent reasonableness: Effective inservice programs provide lesson-related materials and handouts that relate inservice experiences directly to classroom curriculum and instructional practices. The study also reaffirms the complexity of the inservice task and emphasizes the importance of providing teachers with adequate personal access to computers in their own school so they can translate theory into practice. I recommend this excellent report to anyone involved with teacher training or inservice, as we all share the goal of having the inservice experience perceived useful and received well by the busy teacher whom the training is meant to serve.

RESEARCH WINDOWS

Betty Collis

In April's "Research Windows" we feature three studies comparing word processed and handwritten text, and one with an interesting new topic—a comparison of student retrieval skills using print and electronic encyclopedias. Our fifth study is a summary of computer use by math and science teachers, based on a U.S. national survey.

Collis, B. (1988). *An Evaluation of the Program II Severely Learning Disabled (Elementary) Computer Project, Greater Victoria School District #61.* Victoria: University of Victoria Report.

For the past six months I have been conducting an evaluation study of computer usage with severely learning disabled (SLD) students, ages 6-14. The 126 children and nine teachers involved in the computer project received a special grant to allow daily computer use for a one-year period. The SLD children have normal intelligence but, for a variety of reasons, have been unable to learn and typically have serious communication problems. In this project, the teachers learned how to use *AppleWorks* and then every one of the children learned to independently use the *AppleWorks* word processor. A large variety of other software—CAI and problem solving—was also integrated into the children's daily instructional routine. The teachers strongly believed that the computer experiences, especially the word processing, were making a major difference in the children's achievement and self-esteem. However, it was difficult to support these impressions with actual data. For example, we collected three pairs of writing samples from each child, each pair consisting of the first draft of a word-processed story and a paper-and-pencil story done at the same time, and found very few instances of differences in the writing. There was no particular pattern of computer work being mechanically (e.g., capitalization, punctuation, sentence structure) better than the paper-and-pencil work, nor was there a difference in complexity of the two compositions (measured by number of words divided by number of complete thoughts, or T-Units), revision strategies, holistic ratings, or length. There were differences in three areas: Because of the help of a spelling checker, there were differences in number of spelling errors; keyboard entry took approximately twice as long as paper-and-pencil entry; and the students produced neat-looking work with the word processor that, for the first time for many of them, could be displayed at school and taken home with pride. The evaluation covers many different facets of this project, including teacher growth. Information about designing an evaluation of a district computer project can be obtained by writing to me at the address at the end of this column.

Zurn, M.R. (1987). *A Comparison of Kindergartners' Handwritten and Word Processor-Generated Writing.* Unpublished doctoral dissertation, Georgia State University, Atlanta, GA.

In contrast to our results with the SLD population, Zurn observed 67 children in three kindergarten classes who were involved in a Writing to Read project for three months. She compared a handwritten and a word-processed writing sample done by each child and found a clear difference between the two samples: The word-processed writing had more words used, more different words used, and contained more complete thoughts (T-Units) than the handwritten samples. However, there was no difference between the samples on a holistic rating that evaluated the child's overall writing stage development. The word processor "increased the children's fluency . . . but did not enable them to write at a more complex grammatical level" (p. 74). Zurn notes that using the keyboard "did not turn out to be a source of problems" (p. 83), and the computer proved to be especially helpful in making children more aware of word boundaries (through the ease of adding spaces) and of directional principles, as often their handwriting would begin at the middle of the page and then continue anywhere they could find space. Especially interesting for those involved in analyses of the Writing to Read program, the children showed no tendency to make use of the core set of words emphasized in WTR. Only 13% of the word-processed samples and 6% of the handwritten samples contained more than one of the 40 core words, supporting the criticism that the words chosen for emphasis in WTR are irrelevant to the children in their natural use of language. Contact Dr. Zurn through the Department of Early Childhood Education, College of Education, Georgia State University, Atlanta, GA 30303, for more information on this well-done study.

Gerlach, G.J. (April, 1987). *The Effect of Typing Skill on Using a Word Processor for Composition.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

Many people claim that lack of typing skill can be a deterrent to young children's effective usage of a word processor. Gerlach divided 19 fourth grade students into two groups, one of which completed 15 25-minute typing tutorial lessons. All children had the same instruction, and after the typing lessons were completed all were introduced to the same word processor. They used it over a three-month period during which writing samples were collected. Contrary to expectations, there were no differences between the typing tutorial children and the hunt and peck children on any of the variables looked at in the study: length of essays, number of revisions (either at the surface level or the phrase level), and attitudes about typing and writing with a word processor. The result concerning revision is not surprising, as numerous studies have emphasized the importance of instruction on revision strategies, and these children all had the same instruction about revision. However, it was unexpected that lengths of writing samples and attitudes about typing and writing with a word processor did not differ between the groups, indicating again that writing as a process transcends in complexity the tools we use to do it with, and that simple conclusions about writing are not appropriate. For more information, contact Dr. Gerlach at Indiana University of Pennsylvania, University School, 104 Davis Hall, Indiana, PA 15705.

Edyburn, D.L. (1987). *An Evaluation of the Information Retrieval Skills of Students With and Without Learning Handicaps Using Printed and Electronic Encyclopedias.* Unpublished doctoral dissertation, University of Illinois, Urbana-Champaign.

Twenty-eight students in Grades 6-8, including 13 classified as learning handicapped, were given instructions in search strategies appropriate to using a printed encyclopedia and access to two different online versions of the Academic American Encyclopedia. One of these versions, available on DIALOG, involves a command-driven user interface and a full-text search, while the other, available on CompuServe, is menu driven and involves only a title search. Four information retrieval tasks, designated as simple or complex and self-selected or teacher given, were completed by each student using each encyclopedia. Attitude assessments were also collected. The menu-driven electronic encyclopedia was found to improve retrieval success significantly compared to the full-text, command-driven version; however, most interestingly, there was no significant improvement when students used electronic encyclopedias instead of the print encyclopedia. Learning handicapped students were able to successfully handle the three retrieval environments and displayed a more positive attitude toward electronic searching than did the others. Students were also more successful with teacher-assigned searches than with those relating to topics and questions of their own choosing.

This study is valuable because it is one of the first to attempt to study systematically the assumption that many are making—that access to the power of on-line (or CD-ROM) encyclopedia searching will result in impressive differences in students' ability to locate and access information. As usual in education, things do not turn out in such a straightforward manner, and many other variables apparently influence the impact of any educational intervention. This study is especially recommended for its excellent literature review on information retrieval systems. Contact Dr. Edyburn at the Technology Center in Special Education, University of Missouri-Kansas City, 5100 Rockhill Road, Kansas City, MO 64110-2499.

Becker, H.J. (1987). *Instructional Uses of School Computers* (Issue No. 4). Center for Social Organization of Schools, Johns Hopkins University.

In this report on a 1985 national survey of ways U.S. schools use computers, Becker focuses on the use of computers in mathematics and science instruction. Generally, the survey found that relatively little use is being made of school computers with regard to mathematics and science instruction. For example, only 5% of overall instructional usage of computers in Grades 11 and 12 occurs in the area of "traditional math instruction," along with 16% of overall Grade 9-10 usage, 26% of Grade 6-8 usage, and approximately 38% of K-5 usage. In science classes, "Computer use occupied about 6% of the instructional time on computers in high school, roughly 3% in the middle grades, and only 1% in the elementary grades" (p. 2). Those figures, however, do not mean that math and science teachers are not using computers: approximately one-sixth of the science teachers and one-third of the math teachers in the middle and high schools made some use of computers. Becker's data show that this use involves teaching programming or computer literacy, not teaching math or science subject matter.

This report is one of a series summarizing data from a large-scale 1985 survey. The complete set is available for $7.50 payable to the Johns Hopkins University. Write to: Computer Survey Newsletter, Center for Social Organization of Schools, Johns Hopkins University, 3505 N. Charles St., Baltimore, MD 21218.

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we look at an interesting variety of studies. They cover observations of eighth grade students' interactions with on-line encyclopedias: computer conferencing as a teacher inservice experience: preschoolers and the use of mathematics software: Logo and creativity; and an investigation of different search strategies while accessing databases.

Printouts as a Goal of Electronic Searching

Eastman, S. T. (1986). A qualitative study of computers and printouts in the classroom. *ECTJ. 34*(4), 207-222.

Twenty-seven Grade 8 students were given the opportunity to access an on-line encyclopedia via CompuServe for a three-week period to search for information on a science topic. There were nine telephone lines, allowing nine students at a time to be conducting separate searches on CompuServe. One printer was available. Each student had at least four sessions on line. Trained observers paid 62 visits to the class and recorded extensive field notes. Interviews of the students also occurred. "Most of the students found the first experiences (with the encyclopedia) intimidating . . . but typically demonstrated increasing self-confidence as they used the computers for a third and fourth time" (p. 212). Students initially expressed concern about "messing up" and consulted the teacher far more often than the on-screen prompts; these patterns, however, changed as the students gained experience.

This study offers new insights with respect to the value of the printouts obtained by the students. Students spontaneously set a goal of getting a printout, so that it "became an 'end' in itself whereas the teacher intended the printouts as a means toward the goal of writing a theme" (p. 216). Getting a printout was seen as confirmation of mastery of the new technology; not getting a printout was seen as a failure of competency. Some students devoted considerable time marking, cutting, and pasting, or otherwise manipulating the printout, "possibly substituting this for searching the library for print references for their bibliographies or reading other material or writing their themes. . . . Many students decided that manipulating their printouts by tearing them up sheet by sheet, stapling them in groups, crossing sections out, or circling words gave the appearance of being 'at work' in the classroom" (p. 218). Finally, students were content to "abdicate some of their research responsibilities to the computer . . . assuming that whatever was in the computer was 'enough' . . . provided their printouts were as long as other students' " (p. 219). Those of us who have taught Grade 8 can readily relate to these observations; they also remind us that students do not necessarily engage in educationally relevant activities even when comfortable in using a resource with considerable educational potential. Write to Eastman at the Department of Telecommunications, Indiana University, Bloomington, IN 47405.

Females and Computer Conferencing

Dickson, M., Franklin, J., & Hill, A. (1987, June). *Attitudinal changes through computer conferencing.* Paper presented at the Second Symposium on Computer Conferencing and Allied Technologies, University of Guelph, Guelph, ON, Canada.

Over a four-month period 21 female elementary teachers computer conferenced with each other and with 20 graduate students at the Ontario Institute for Studies in Education. The students were taking an on-line course about women and computers in education. The 21 teachers who were chosen to participate indicated at the beginning of the project that they were aware of gender differences in computer use in their own schools, among both students and teachers, but they were not particularly concerned about these differences. Over four months they read on-line course materials and participated as extensively as they wished in regular on-line conferencing with the graduate students. The teachers did not have experience with modems and telecommunications prior to the project, but they learned quickly: Within the first 10 days the participants wrote 400 conference comments and 900 personal notes. After the four months were over, the teachers were asked to comment on the impact of the experience. Their reactions were very positive, particularly with respect to their attitudes about their own facility with the technology. The teachers also indicated a greater awareness of gender differences in computer usage and an enlarged set of strategies for correcting this inequitable usage. The teachers felt that the continuing interchange of ideas on line "allowed each participant to contemplate the issues more fully than they might at a one- or two-day face-to-face conference" where personality styles sometimes act as barriers to communication. "Computer conferencing allows each participant to contribute on an equal basis and get equal 'air time,' " a significant factor in a project whose goal was to change attitudes. The teachers indicated their experiences with telecommunications changed not only their own attitudes about gender imbalance in computer use, "but also those of their administrators, colleagues, family members, and students." This project has much to recommend it: for example, this could be a valuable way to combine telecommunications and teacher inservice at the local level. Contact the authors care of Dr. Dorothy Smith, OISE, 252 Bloor St. W., Toronto, ON, M5S 1V6, Canada.

Preschoolers and Mathematics Software

Massey, C., & Gelormino, J. (1987, April). *The influence of a math software program on preschoolers' acquisition of mathematics: 'Ruton' in the classroom.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

In this study 66 preschool children (mean age 47.9 months) from three university-based early education centers were matched within each site on age, sex, and scores on number concepts tests given in an interview format. After the matching, one child from each pair was randomly assigned to a group that had ongoing access to a computer as one of the learning centers in the classroom. The other child from each pair was in a group with no computer access. The study lasted for eight weeks. The software chosen for the children was a mathematics number concepts program called *Ruton*. (This program is not described in the study.) Logs were kept of the amount of time each child used the computers (use was voluntary); videotaping of student interaction with the computers was done during the first, fourth, and eighth weeks of the study; and the number concepts interview test was again administered during the week following the eight weeks of computer use. The children with computer access had significantly greater gain scores on the number concepts test than the children without this access, and as a group the mean posttest score of the computer-using group was significantly higher than that of the non-computer group. There was no difference in the amount of time boys and girls spent at the computer, nor was there a relationship between pretest score as a measure of prior readiness and time spent using the computer. The authors conclude from this that young children who have low levels of mathematics achievement can be comfortable using math software and can benefit from the interaction. The videotapes showed that even the youngest children could learn to use the computer comfortably and independently. Like most studies of young children, this study has some methodological problems; however, the results can contribute to our overall expectation that computer use can have an impact on learning mathematics for young children. For more information, write to Claity Massey, Director, The Houghton College Demonstration Day Care Center, Houghton College, Houghton, NY 14744.

Logo and Creativity

Plourde, R. P. (1987, December). The insignificance of Logo—Stop 'mucking around' with computers. *Microscope*, Logo Special Issue, pp. 30-31.

The author of this study is a classroom teacher who has been a keen user of Logo with elementary students. He attended a meeting in which Henry Becker, research scientist at Johns Hopkins University, told the 60 teachers present to "stop mucking around with computers." Plourde did not feel he was "mucking around" with the variety of Logo experiences his students were undertaking, but he decided to respond to the challenge to "put his program to the test." To do so, he selected two Grade 5 teachers in his school from those who volunteered to participate in his study. The two classes were matched on various variables and judged to be reasonably similar. Each class had one hour in the computer laboratory per week for 36 weeks. One class used Logo, the other did non-Logo activities involving word processing, an adventure game called *Zork*, and science simulations from MECC. The Logo group was given instructions in basic Logo commands, but few creative uses of Logo were demonstrated. "This was purposefully allowed to 'see' if Logo could 'stand alone' as a facilitator for the creative process in the areas of fluency and flexibility" (p. 31). After the 36 weeks, all the children were given the fluency and flexibility scales of the Torrance Tests of Creative Thinking. The non-Logo children scored significantly higher on the fluency test than did the Logo children, and there was no difference between the groups on the flexibility scores. Plourde concludes, somewhat reluctantly, that "perhaps Logo, in and of itself, is not as significant as the classroom teacher who provides a stimulating environment and ensures that creative activities are part and parcel of the students' lessons on a regular basis" (p. 31).

This study also has methodological problems; however, it is an excellent example of the kind of action research that classroom teachers can and should be doing. Through the accumulation of many studies such as Mr. Plourde's, we will come to have a much better and more disciplined view of the impact of computers in the classroom; and teachers, rather than academic researchers, are in the best position to do these "real-classroom" studies. Write to Mr. Plourde care of the editor of *Microscope*, Senga Whiteman, Newman College, Bartley Green, Birmingham, UK, B32 3NT.

Database Search Strategies

Beishuizen, J. (1987). CIR: A computer coach for information retrieval. In J. Moonen & T. Plomp (Eds.), *EURIT 86: Development ... cational Software and Coursew...* ...7). Oxford: Pergamon Pre...

Beishuize... ...no is a cognitive psychologist and a member of ICCE's International Committee, designed and tested "computer coach" software that "closely monitors the students' behavior and gives tutoring advice as soon as misconceptions occur" (p. 21). The task in the study consisted of having 14- to 15-year-old students search for information in two databases. One contained 180 relatively unstructured records relating to the Golden Age in Amsterdam; the second was a set of 210 relatively well-structured records about job descriptions. Key words for each of the databases were given to the students. Half the students were coached during the retrieval process by software-generated hints which guided them to use either a depth-first or a breadth-first strategy. (A depth-first strategy aims at an intermediate reduction of the search space by entering as few keywords as necessary. A breadth-first strategy attempts to initially build up as complete a picture as possible before systematically reducing the search space.) The other half of the students received no hints from the program.

A number of interesting observations were obtained. Although it did not interfere on two consecutive moves, the coach interrupted too often for some students and "annoyed" them. Coaching was more effective than noncoaching with the weakly structured Amsterdam database, with the first-depth students profiting more from the coaching than the breadth-first students. (The search method was assigned by the researcher.) However, there was no difference in effectiveness between coaching and noncoaching (as measured by time required to retrieve and quality of retrieval) with the well-structured job description database. Students were also given a new database to search without any coaching. Students using the breadth-first strategy tended to do better on the transfer task. From all this, Beishuizen concludes that different strategies are appropriate for different degrees of structure in a database, but that a depth-first approach, which appears to be more effective with a less-structured database, does not transfer to new database environments as effectively as the breadth-first strategy.

This is the sort of patient, basic research that is needed to gradually improve our sensitivity to critical variables in our choice of instructional strategies for student use of databases. Contact Beishuizen for more of his studies at the Free University, de Boelelaan 1115-C113, 1081 HV Amsterdam, The Netherlands. He is doing particularly interesting work on the impact of different learning styles on students' responses to computer coaching.

RESEARCH WINDOWS

This month's "Research Windows" contains five studies: three relating to special education. one on learning styles in relation to preferred type of computer use, and one on the development and evaluation of a "Logo Thinking Skills" curriculum.

As the school year is ending, I would like to thank all those who have sent me studies to review for the column or questions relating to the integration of research and practice. I am always pleased to hear from you and to note your thoughtful approach to the complex but rewarding task of thinking critically about computer applications in education.

Spelling Drill and Students with Learning Disabilities

MacArthur, C. A., Haynes, J. A., Melouf, D. B., & Harris, K. (1987, April). *Computer assisted instruction with learning disabled students: Achievement, engagement, and other factors related to achievement.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

This study compared the effects of paper-and-pencil and computer-delivered independent drill and practice in spelling over a four-week period with 44 students with learning disabilities in Grades 5 and 6. Students from six self-contained LD classrooms were randomly assigned to learning-center groups involving either computer drill or written drill. The content of the drills was the same, and all students used a 20-minute timer to hold potential practice time constant. Feedback procedures varied between treatments, as traditional work generally was marked by the teachers and returned the following day while the computer drill provided immediate feedback and targeted practice. Weekly spelling tests were given before, during, and after the treatments. In addition, student task-engagement level was tallied during one lesson per week, at 15-second intervals during these lessons. Also, attitudinal measures were administered.

Computer-practice students did significantly better overall ($p < .01$) than the traditional drill students on the spelling tests; they also spent "significantly more time engaged with academic content and significantly less time off-task" or interacting with their teachers than did traditional drill students. Type of drill was not related to any of the attitudinal measures. Through various statistical procedures the authors conclude that "well designed CAI can be an effective means of maintaining high levels of task engagement during independent practice and increasing spelling achievement for LD students" (p. 1). For more information about this very well designed and carefully done study, contact the authors at the Institute for the Study of Exceptional Children and Youth, Department of Special Education, University of Maryland, College Park, MD 20742.

Survey of Computers and Students with Special Needs

Mokros, J. R., & Russell, S. J. (1986). Learner-centered software: A survey of microcomputer use with special needs students. *Journal of Learning Disabilities, 19*(3), 185-190.

Special educators in 50 U.S. school districts were surveyed concerning computer use with students with special needs and in particular the comparative usage of drill and *learner-centered software* (I like this phrase). Word processing was "by far" the most widespread example of learner-centered software which had been used by the teachers (27%). "Of all the available software, a total of only eight different non-drill titles were mentioned" (p. 186). When learner-centered software was used, "its actual use did not always reflect the potential of this software," as "teachers frequently used learner-centered software either for drill and practice or for reward and motivation," such as using a word processing program to deliver a set of misspelled words for the student to correct. Teachers believed there was particular value in having students type, perhaps so the students could better see mistakes or to "slow down impulsive students." When writing was involved, word processing was primarily used for mechanical error correction rather than as a way to enrich the writing process. Furthermore, "not one teacher reported receiving training on how to integrate educational software into the curriculum" (p. 187). The authors disucss these data and make a number of good recommendations which are just as valuable for teachers of regular students: Provide models of instructional strategies, provide time for teacher familiarization, provide continued teacher support after inservice, and articulate clearer objectives for student use of computers. This useful study is representative of the work coming from a large-scale project, "Microcomputers in Special Education: Beyond drill and practice," of the Technical Education Research Center, 1696 Massachusetts Ave., Cambridge, MA 02138. Contact the authors at this address.

Learning Styles and Simulations/Tutorials

Rowland, P., & Stuessy, C. L. (1987, April). *Effects of modes of computer-assisted instruction on conceptual understanding and achievement of college students exhibiting individual differences in learning: A pilot study.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Washington, DC.

Can aspects of an individual's learning style predict whether a student will work more profitably with a simulation or with a tutorial in terms of subsequent performance on measures of conceptual understanding and scores of an achievement test? This question was investigated using a sample of 51 elementary education majors who were given a battery of learning style inventories and then randomly assisnted to use of either a simulation or a tutorial relating to home energy use.

The sampel in this study was too small to support the many statistical tests applied to it without risk of overinterpreting the results. However, certain trends are interesting, such as the observation that "specialists," people who use a "local approach, concentrating on narrow procedures before an overall picture emerges" (p. 4) may have more difficulty in learning from simulations than people who are "holists," who prefer to first build a broad description and then fit in details as they learn a new concept. The authors found that when students were matched to condition, with serialists using tutorials and holists using simulations, achievement was significantly higher on a subsequent written test than when serialists and holists were "mismatched" with computer program types. The major value of this study may be in its contribution to our increasing awareness that simple generalizations cannot be made about the effectiveness of any particular type of computer use; student learning styles are but one of many clusters of variables which critically influence effectiveness. For more information on this study, write to the authors at the College of Education, Department of Curriculum and Instruction, Box 3CUR/Las Cruces, NM 88003.

Logo and a Thinking-Skills Curriculum

Hunter, J., Kempt, T., & Hyslop, I. (1987). *Development and evaluation of the "Thinking with Logo" Curriculum.* Edmonton, Alberta: Alberta Education.

This is another study that shows the strong influence of contextual variables on the effect of a computer intervention in the classroom. The report summarizes development of a curriculum that uses Logo "as a medium for the learning of cognitive skills that are necessary for problem solving" (p. iii). The curriculum, encompassing Grades 1-6, and its rationale (the theory of "structural cognitive modifiability") are carefully presented. Methodology for teaching the curriculum was developed and modeled. Six elementary schools were randomly assigned to "Thinking with Logo," traditional Logo, or control groups, and Grade 3 and 5 students from these schools took the Canadian Cognitive Abilities Test as both a pretest and posttest. Teachers in the thinking skills schools received released time to attend a two- to three-day workshop on the new curriculum.

The study was not able to find an advantage associated with the "Thinking with Logo" curriculum for either the verbal or quantitative skills of the CCAT test, and improvements on the "nonverbal" scale of the CCAT favored the traditional Logo groups, not the "Thinking with Logo" groups (the latter was not significantly different from the control group on this posttest subscale). The evaluators belive the "failure of this study to demonstrate measurable differences on the CCAT in no way suggests that the curriculum was ineffectual" (p. 25) and note a number of contextual variables which could have influenced the result. A major possibility is the "teachers' lack of familiarity with a mediational teaching style" despite their inservice support. This report is recommended for those interested in the careful development of a Logo/Thinking Skills curriculum, those who are interested in program evaluation, and those who are concerned with critical variables affecting computer-related instructional impact. For a copy of the report, write to Mr. Gary Zatko, Alberta Education, 5th Floor, Devonian Building, West Tower, 11160 Jasper Ave., Edmonton, AB T5K 0L2, Canada.

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Research Windows, Volume 16
1988-1989

RESEARCH WINDOWS

Betty Collis

This column begins my fourth year of writing "Research Windows." Instead of using the standard format—summarizing a set of research studies that meet my criteria of being well done and useful for the classroom teacher—I would like to use this month's column to make some general observations about my perceptions of research in the application of computers to education.

I am frequently asked. "What does the research tell us?" about a certain topic. In collecting my thoughts to try to answer this type of question. I have become aware that there are three major messages in computers in education research studies. I think each of these messages is as important for the classroom teacher and the school decision maker as it is for the researcher. These messages are:

- There are no easy answers or simple conclusions about computers in education;
- Teachers are critically important in whatever happens when computers are used in education; and
- Classroom implementation of computers is proving to be more difficult than we expected.

Each of these points offers both good and bad news to the classroom teacher.

There Are No Easy Answers

The strongest message I get from the research literature is that there are no easy conclusions about the impact of computers in education. There are certainly general trends that can be reported in terms of describing current computer use. For example. we know that most North American schools have multiple computers and that *computer literacy* is now more generally defined in terms of using applications software than doing programming. We also know from our own personal experiences that exciting learning experiences are taking place in classrooms where teachers use computers. But in terms of drawing conclusions from the research about the impact of computer use on certain aspects of learning. for example on problem solving or on student achievement in curriculum areas. we just can't make simple conclusions.

Sometimes this is because there are problems with the research studies themselves. A researcher named Clark. for example, reexamined 128 studies that had been used as the basis of a widely cited series of research summaries (meta-analyses) done by teams headed by another researcher named Kulik. Clark found that in most of the studies that comprised the meta-analyses there were noncomputer differences between the computer and non-CAI groups that could have contributed to the differences in the results that were found for the studies; as. for example. would occur if the CAI group received more instruction or better prepared instruction than the non-CAI group.

However. the lack-of-an-easy-answer aspect can be found even within well done studies. Encouraging results that occur in one situation and study often are not replicated in another situation and study. This can be seen even in the research relating to the highly valued application of word processing as a writing tool. We know from our own experiences that good things can happen when students use word processing, but we also know from the research that these good things do not happen automatically. So much depends on what students are taught about components of the writing process. such as planning and revision. and how the teacher organizes use of the computer as a writing tool. Because these things vary across studies we see a wide variety of results and realize that as yet no clear conclusion can be made from the overall word processing literature about the impact of word processing on writing skills.

So when I try to summarize studies such as the word processing research. the major conclusion I find is that the impact of computers on any aspect of learning very much depends on all sorts of other factors in the situation in which the computers are being used, such as student and teacher characteristics. the instructional strategy in which the computer use is embedded. the social organization of the classroom and of the computer use experience. the physical organization of the computer facilities. and characteristics of the software and hardware involved in the learning activities. There is just no easy answer. What works very well in one classroom may not work as well in the next. Everything seems to depend on a complicated network of variables. and I think the most important variable of all is the teacher. So what is the good news? The same as the bad news—that the potential exists for making effective use of computers in education. but the extent to which this will happen depends on so many things that we can't yet make a general conclusion about the positive impact of computers in any particular area of learning and instruction.

The Importance of the Teacher

A second message that comes through repeatedly when I read the research literature is the central importance of the teacher in any kind of computer utilization. Levin. for example, compared the effectiveness of the same computer-based mathematics and reading drill material (the CCC system) in a variety of classrooms and found wide variation in the impact of the materials. That this can occur with very structured and well done stand-alone drill material indicates how magnified the teacher's effect will be with less structured uses of computers such as simulations; microcomputer-based laboratory work. and applications software uses, such as word processing. database. and spreadsheet activities. We see from both research and practice that the teacher is probably the critical variable in all of these more open-ended types of computer use. The teacher must find an appropriate and meaningful use of the computer application relative to the content to be conveyed through the computer use, to the characteristics—both cognitive and social—of the students, and to the overall style of instructional organization and management the teacher prefers. We have evidence, for example, that teacher decisions to structure computer use for groups of students—as contrasted to students working individually—can make a difference in the effectiveness of the computer use, at least with respect to learning from a particular computer simulation. It is my personal belief that the teacher remains, as always, the major influence on the effectiveness of any sort of computer usage in schools. I believe, for example, that a good teacher can make significant use of limited resources such as an old-fashioned, simple BASIC program and a single classroom computer. This is the good news.

The bad news has at least two aspects. One is that the great potential of computer use for classroom instruction will probably not be reached, in my opinion, by teachers who lack the imagination, will, skill, or energy to blend appropriate computer use into their teaching. The second bad news aspect is that it still isn't easy in many situations to use computers as part of instruction. Rather than reducing the teacher's work load, it still generally takes time and effort to find ways to integrate and manage computer use in classroom instruction. Not having adequate time to prepare for, reflect on, set up, or manage computer use is a major problem for teachers.

Diffusion Barriers

The lack of adequate time is probably an important factor in the third message that I frequently find in the research literature (and in the field). This message is that the spread, or diffusion, of computer use into classroom curricular instruction is proving to be more slow and difficult than we may have expected it to be. Although there are now many machines and software packages available, we know that actual usage in the context of curriculum based instruction is still frustratingly limited. My own data, for example, from a 1987 survey of 3,000 Grade 11 students in urban areas throughout Canada, show that over 80% of these students had never used a computer in the context of their mathematics, science, or English instruction, and over 90% had never, even once, used a computer in the context of their social studies instruction. There are very similar data from a U.S. study, published in 1988 by the Educational Testing Service.

Why is this diffusion slow, given all the good ideas and energy and time spent on the acquisition of school computer resources? I think the research literature gives us at least two clues. One is that teachers do not yet have models, either in their training or during their regular service, of strategies for implementing and managing computer use in the actual classroom setting. A second clue may be found in the literature that looks more generally at teachers' responses to innovations in schools. The work of Hall and his colleagues on the "concerns-based adoption model," for example, describes a series of predictable "levels of concern" that teachers move through when they encounter an innovation in the school setting. Awareness of models such as Hall's can help us to plan more effective inservices and to help teachers identify reasonable goals for their own immediate progress with regard to computer use in their classrooms.

I think, therefore, that the overall message from my third area of research trends is more of a bad news message than a good news message. Despite the efforts of so many, we apparently have not yet found an effective way to convince the majority of our colleagues that they should use the computer as an instructional tool.

What Shall We Do About It?

As I read research studies, the messages that come most strongly to me, regardless of whether they are stated explicitly, are those I have just discussed. What do they mean to me, as a teacher trainer, a researcher, and an ICCE member? I think they make me cautious and somewhat concerned. I see clearly that we need to find more effective ways to serve, support, encourage, and convince teachers to explore the use of technology in their classrooms. I also think the impact of computer use in particular classroom situations is too complicated to predict, even though I would like to be able to make some general claims about the value of various types of computer use in instruction.

What do the messages say to the classroom teacher? I think they tell us that we are still pioneers, that things are not yet *simpler* because of computer use, and that outcomes may still not occur as we hope or in ways that we can clearly identify. Despite all this, I remain optimistic. I will make a special effort for this year's "Research Windows" to look for studies that can provide implementation guidance for practitioners. I encourage you to send me information about good research studies that highlight the teacher variable in computer use. I believe ICCE, with its large international membership of both practitioners and researchers, can continue to play a key role in advancing the research base in our field by bringing together teachers, teacher trainers, researchers, policy makers, and hardware and software developers, and through this process can help identify variables constraining or helping teachers as they make use of computer related technology in educational practice.

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RESEARCH WINDOWS

Betty Collis

This month's "Research Windows" covers five diverse studies. The first examines the impact of word processing on the planning process college students and faculty use to write. The second assesses the impact of computer simulations on problem solving skills. The third compares the social interaction and problem solving skills of two groups of young children: those using Logo and those using drill and practice programs. The fourth looks at the effects of computer access and flowcharting on programming. And the final study examines individual variation in natural curiosity among Grade 8 students interacting with computer programs.

Word Processing and Planning for Writing

Haas, C. (1988, April). *How word processing affects planning in writing: The impact of technology.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Many studies have explored the impact of word processing on how students plan for writing. The majority of them seem to conclude that writers may plan less when using word processing than when not. Haas summarizes a number of these studies and notes that reasons may include an overemphasis on surface revisions at the word and sentence level because of the ease of tidying up and "fooling around" with particular words and phrases. Other reasons may be that planning notes are more difficult to create and manipulate when using a word processor or that writers are inhibited by difficulties in re-reading their text because only so much appears on the screen at any time, causing writers to look at surface problems in isolated segments rather than considering the overall entity. Haas notes, however, that the studies that contribute to these conclusions often have limitations, such as failing to distinguish between experienced and inexperienced writers or word processor users. Her study in contrast is well designed and builds upon the research she summarizes.

Haas used a "think-aloud" methodology to collect the thoughts of 20 writers, all experienced users of a particular advanced word processing system allowing for on-screen notes and a preview window of completed text. Half of the subjects were experienced staff writers, the other half second-semester college freshman. Each subject prepared three texts—one using only the word processor, one using only pencil and paper, and one using any combination the writer wished of machine and pencil. Writers were instructed to say everything they were thinking, from the time they started to plan until they felt their texts were completed. Haas found that when using pencil and paper alone, significantly more total planning took place, more initial planning occurred, and more conceptual planning occurred, and that there were no particular differences between the two word processing conditions with respect to any type of planning. At the same time, significantly more surface level planning occurred with word processing compared to pencil and paper. Surprisingly, there were no differences between the student writers and the faculty writers in these results.

As I thought about this study, I observed something about my own writing. Instead of first writing this "Research Windows" summary by hand, as I usually do, I have written it directly onto the computer. The difference I noticed in my own planning relates not to Haas' initial, conceptual, or surface planning stages, but rather, to space and content planning—I have written much more and allowed my thoughts to expand more freely than I would by hand (e.g., this entire section about my own reflections). I think the reason for this is that with paper I know just how much space corresponds to a section of the "Research Windows" column; on the computer, there is always more space even though, intellectually, I know how many lines I have used. Is this a part of planning? Am I writing any better because I am saying things I had not planned to, but that evolved as relevant? Haas notes that word processing writers may evaluate their writing more even though they plan less; perhaps I am. In any case, this may be a profitable area for future word processing research. For more information, contact Haas at English Department, Baker Hall, Carnegie Mellon University, Pittsburgh, PA 15213.

Problem Solving and Simulations

Woodward, J., Carnine, D., & Gersten, R. (1988). Teaching problem solving through computer simulations. *American Education Research Journal, 25*(1), 72-86.

How can we assess the impact of computer simulations on student learning and higher level thinking skills? Frequently studies that try to address these questions fail to consider the instructional environment that accompanies the simulation. In contrast, this study gives us a detailed description of very carefully planned instructional procedures used to integrate a health care simulation into a unit on the diagnosis and change of health habits for high school students who are learning disabled. An equal number of students in each of three LD classes (30 students altogether) was randomly assigned to either a computer or traditional group. Both groups shared the same first half of each of 12 daily lessons. During the second half of each lesson students focused on the diagnosis of poor health habits, either using traditional methodology or a computer simulation. Those using the simulation were guided by teachers through early computer runs, with the express purpose being that they become more aware of how to apply various problem solving strategies to the diagnostic problems posed in the simulation. The same teachers worked with both groups. Tests on knowledge acquisition and health problem diagnosis were given to all the students in the study as well as to same-age nonhandicapped students taking health courses based on similar material in the regular school environment. The LD/simulation students not only did better than the LD/traditional students, but also significantly outperformed the regular classroom students on the problem solving diagnosis test. The researchers believe that a key component in the success of this computer simulation implementation was the guidance the LD/simulation students received during their initial use of the simulations; giving them explicit strategies for successful performance on the simulation seemed to help them transfer these strategies to another diagnostic task using a noncomputer medium. I recommend this study not only because it is well done (and encouraging), but also because the strategies used within it for implementing a computer simulation can be of value to any teachers attempting to manage effective use of simulations within their own classrooms. As usual, it is not computer use in itself that has the most potential for impact, but computer use embedded within a larger framework of good teaching practices.

Logo and Problem Solving—Another Look

Clements, D. H., & Natasi, B. K. (1988). Social and cognitive interactions in educational computer environments. *American Educational Research Association Journal, 25*(1), 87-106.

Ever since Papert first presented the argument that Logo work could involve even young children in high-level metacognitive activity, researchers have been trying to verify Logo's impact. Clements' work is well known in this area. In this study he and his colleague present a careful comparison of 48 children, half in Grade 1 and half in Grade 3, randomly assigned to 28 sessions of either Logo or drill and practice work. Children in both types of computer groups worked in pairs and were observed in terms of their social interaction and also in terms of various indices of "metacomponential" (or problem solving) activity. When significant differences were found between the groups, they favored the Logo group. These differences occurred in three of the seven categories of social behaviors defined for the study (resolution of conflict, self-direction, and rule determination) and one of eight problem solving categories. Therefore, the support for Logo compared to CAI experiences as correlates of higher level problem solving activity is at best limited in this study. However, the support for Logo as a stimulus for desirable social interactions likely to be related to subsequent problem solving behaviors is more substantial. Perhaps the most helpful aspect of this study is the careful elaboration of different aspects of problem solving activity and associated social behaviors. I think that part of our difficulty in demonstrating the impact not only of Logo but of computer experiences in general relates to our frustration at not being able to identify and measure the higher level learning that we feel confident is occurring. Clements and Natasi present useful categories of different types of social and metacognitive activity and give examples of actual student responses that relate to each of these categories. Although the authors acknowledge various limitations in this study and state that "caution should be used in drawing implications" from it, I believe it makes a valuable contribution to Logo-related research as well as to our better understanding of how children think and learn while interacting with one another in a computer environment.

New Insights in Programming Instruction

McCormick, D., & Ross, S. M. (1988, April). *Effects of computer access and flowcharting in learning computer programming*. Paper presented at the annual meeting of the American Educational Research Society, New Orleans, LA.

Do all students need the same access to computers and to make flowcharts when learning to program? Seventy-two high school students enrolled in four sections of an 18-week computer literacy course were randomly assigned to four groups. The groups experienced different combinations of having limited or unlimited access to classroom computers and were either required or not required to develop flowcharts as part of programming assignments. The same teacher taught all the classes. Interesting results were found. Students who were not required to submit flowcharts scored higher on programming posttests than students who were required to produce flowcharts. Also, having limited access to a computer (sharing a single computer among 7 to 10 students for testing code) resulted in better achievement for middle and high ability students than did having unlimited access to individual computers. The authors offer a reasonable interpretation of these results. They believe the flowcharting result suggests that a limited or inadequate understanding of flowcharting concepts (probably likely to be the case for many high school students) may interfere with rather than help programming understanding. (This reminds me of the idea, "A little learning is a dangerous thing.") They also suggest that for higher ability students, having limited access to a keyboard means they are less likely to move prematurely to the entry of code. Instead, they may be forced by circumstances to do more planning before sitting at the keyboard. For low ability students, however, having unlimited access means more immediate feedback is available, giving them support they may not be able to provide for themselves in a planning situation. The authors recommend deliberately providing unequal computer access for students learning programming, giving additional computer time to "low achievers who have greater need for the immediate and concrete feedback of online activity" while requiring other students "to spend more time designing and mentally simulating procedures away from the computer." I like these recommendations; for one thing, they support the importance of instructional strategy rather than a blanket advocacy of more hardware support and should be encouraging to those who believe their students are at a disadvantage if they have only limited access to computers. For more information contact Dr. Ross at Foundations of Education, Memphis State University, Memphis, TN 38152.

Natural Curiosity and Computer Exploration

Lancy, D. F. (1988, April). *Individual variation in working/playing with computers*. Paper presented at the annual meeting of the International Association of Computing in Education, New Orleans, LA.

In this short study Lancy begins with the observation that his own children appeared to lose their natural curiosity about computing as a result of negative school and social experiences. Because he believes that computers can stimulate intelligent and purposeful exploration that can "enlight as it entertains," he developed activities for a Grade 8 computer course that involved using software (*Ranch*, *Pinball Construction Set*, and *Rocky's Boots*) that he thought would embody a naturally attractive experience. He then observed 16 students who were given free opportunity to experiment with these programs. He found that none of the students were sufficiently interested in the programs to go through all of the program construction sequences; in fact, some did nothing more than push buttons relating to various options and "turn thumbs down" on opportunities to even try some of the software. He concludes that "these programs, as good as they are, must be embedded in a curriculum" as "some students have mental schemas for learning which fit the demand characteristics of these creative programs, while others can only follow explicit directions from a teacher." This observation parallels my own philosophy that it is the teacher, not the software or the access to hardware, that is the critical variable in learning with computers, at least for the majority of students. For more information on the study, contact Lancy at the College of Education, Utah State University, Logan, UT 84322-2805.

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RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows," I discuss three studies comparing the impact of computer drill with the impact of paper-and-pencil drill for elementary school students. I also summarize an excellent review of research on text and graphics display decisions and another study on gender stereotypes associated with computer study.

CAI and Sixth Grade Mathematics

Mevarech, Z. R., & Ben-Artzi, S. (1987). Effects of CAI with fixed and adaptive feedback on children's mathematics anxiety and achievement. *The Journal of Experimental Education, 56*(1), 42-46.

In three Israeli schools, 245 sixth grade children were given six different measures of anxiety toward mathematics at the beginning and end of the school year. They also took a standardized, nationwide mathematics achievement test at the end of the year. Children were classified as high anxious or low anxious toward mathematics based on their responses to the attitude battery at the start of the school year. Children in the three schools had "the same basic group instruction," curriculum material, and time allotted for mathematics instruction throughout the year. Two of the schools provided two 20-minute drill and practice CAI sessions per student per week; while the third school had no computer usage within the context of mathematics. The two CAI treatments differed in that the "adaptive" one gave more effusive reinforcement to correct answers on "difficult" problems (word problems and fractions) than it gave to other problems, while the second CAI treatment gave the same very good, good, and correct feedback to correct answers regardless of the difficulty of the problem. In addition, the adaptive feedback treatment summarized only correct responses in student summary data while the fixed feedback treatment gave a summary of both correct and incorrect responses.

At the end of the year there was no significant difference in achievement between any of the groups of children, nor did it matter whether initially high-anxious children were in one of the CAI schools or the non-CAI school. However, there were significant differences in end-of-year anxiety on two of the six anxiety subscales (Worries About Learning Mathematics and Attitudes Toward Learning Mathematics with Computers), and both of these favored the CAI groups compared to the traditional group. There were no differences on these subscales for the two types of CAI feedback.

Although it is encouraging to get some support for computer use in sixth grade mathematics practice, the support is modest at best ($p < .05$ for only two of seven tests). The authors assess this limited impact and suggest that the teachers may have had difficulty adapting to the new technology and that this may have "weakened its efficiency."

I know the teacher variable is important, but I suspect the overall lack of difference in this study comes from accumulating data over all students and teachers. My feeling is that we need more sensitive hypotheses. Looking at the children who appeared to do better than expected after the computer experience may be a way to generate such hypotheses, which can then be investigated in other settings. For more information on this study, contact Dr. Mevarech at Bar-Ilen University 52 100 Ramat Gan, Israel.

CAI and Third Grade Mathematics

Campbell, D. L., Peck, D. L., Horn, C. J., & Leigh, R. K. (1987). Comparison of computer-assisted instruction and print drill performance. *Educational Communication and Technology Journal, (ECTJ), 35*(2), 95-103.

Matched pairs of 48 third grade students in one school were randomly assigned to a CAI or non-CAI group. All pairs of students received the same daily mathematics lesson, taught by the same teacher, during a five-week period. In addition, all children spent 20 minutes per day doing mathematics drill on division. The CAI children used the *Milliken Mathematics* software with 50 levels of division problems; the non-CAI children were given paper-and-pencil worksheets consisting of problems randomly generated by the *Milliken* software for each of the 50 levels of difficulty. Children in both groups had to maintain the same passing level (70%) or were dropped to a previous level, and they had to achieve the same mastery level (90%) to move up to the next level. CAI-using children were given immediate feedback by the program on all problems; non-CAI children apparently only got feedback after a work sheet was completed (the article is not clear on this). Each week all students were given equivalent 50-item paper-and-pencil tests containing division problems from all 50 levels. Mastery was defined as getting 50% correct.

What happened? There was no difference in achievement between the two groups at any time except after Week 1, and that difference favored the paper-and-pencil group. A more conclusive finding was that more children in the paper-and-pencil group reached the 90% mastery level than did the CAI children. For example, 71% in the paper group reached mastery by the end of Week 2 compared to less than 50% in the CAI group. The authors suggest this was because non-CAI children could move from problem to problem without delay and interruption, while CAI children had continual waits for reinforcement. The authors also note that efficiency as well as achievement should be considered in CAI studies.

Although I do not agree with some of the comments made in the article, the findings interest me. As we have seen in other studies both with and without computers, continual reinforcement and forced interaction may be counterproductive for learners already familiar with concepts. The data from the study also suggest considerable time was wasted for many of the children who reached mastery in the weekly tests but still had to work their way through level after level of drill—either by computer or worksheet. For more information, contact the authors at The University of Alabama, University, AL 35486.

Computer Drill and Motivation

Seymour, S. L., Sullivan, H. J., Story, N. O., & Mosley, M. L. (1987). Microcomputers and continuing motivation. *Educational Communication and Technology Journal* (ECTJ), *35*(1), 18-23.

Unlike the first two studies, this research gives us clearly encouraging results about the benefits of computer delivered drill compared with paper-and-pencil drill, in this case with respect to student motivation to learn. Six classes of fifth and sixth grade children (n=139), all familiar with computers, studied a science unit on energy. Two sets of questions, eight items each, were prepared. Half of each set were "easy" (multiple choice with three choices), and half were "hard" (recall and supply items). The identical questions were presented to the children on a computer or by paper and pencil. The only difference in presentation was that feedback about being correct was given after each item on the computer and after each set of eight items otherwise. Students heard items read aloud before they answered. After finishing the items, all students were given a six-item questionnaire probing their attitudes toward mode of work (computer or paper and pencil), perceived difficulty of questions, mode preference for subsequent work, and interest in the subject of energy. The results are interesting.

Although there were no differences in success rate between the two media and no differences in time spent on task (nor on the content of the questions), students in the computer group rated the learning as more interesting than did the students in the paper-and-pencil group. In addition, significantly more of the computer students than the paper students thought they did better on the quizzes and that the quizzes were easy, and indicated a desire to study energy again. Nearly all the children indicated they would prefer to do subsequent exercises on a computer than on paper.

We cannot isolate the effect of the computer from that of providing immediate feedback after each item, so we cannot say the computer itself caused this powerful effect on perception and motivation. However, the study is highly encouraging, especially in this potential translation of a simple computer delivered exercise into a desire to study more about the subject content of the exercise. For more information write to Dr. Seymour at the Department of Educational Technology, Arizona State University, Tempe, AZ 85257.

Factors Influencing the Learning of Electronic Text

Hartley, J. (1987). Designing electronic text: The role of print-based research. *Educational Communication and Technology Journal (ECTJ)*, *35*(1), 3-17.

In this well-written and informative article, Hartley summarizes over 100 research studies and syntheses covering the impact of the design and presentation of text and graphics on learning. His discussion is relevant to both screen-based text and desktop publishing, and it focuses on three general topics: layout of text, typographical cues, and decisions about graphics.

There are many important insights consolidated into this article. I would recommend it to any graduate student, researcher, or software developer as an up-to-date examination of the complexity of issues underlying the seemingly simple matter of deciding how to arrange text on screen or paper.

Some of Hartley's conclusions are: Unjustified text is more suitable than justified, especially for less able readers; numbering and indenting lists of points makes them easier to recall; units of line space should be consistent from screen to screen; learners prefer spaciousness—designs with generous amounts of white space and openness—and displays that are organized in chunks with headings; learners read all capitals more slowly than they do upper and lower case text; multiple cues such as using both color and underlining may be less effective than single cues, but readers, especially children, need to be told what the cues signify before they can appreciate the cues' import. The study also makes valuable observations about graphics (e.g., line graphs are better than bar graphs for showing trends); menus (pull-down menus arranged in a tree-like manner may not be as good as other arrangements for certain learners); and scrolling (reading scrolling text is more difficult than reading static text). The principles Hartley discusses are also important for classroom teachers as they make decisions about software effectiveness for their students. For more information, contact Hartley at the Department of Psychology, University of Keele, Staffordshire, U.K.

Different Results about Gender Stereotyping and Computers

Siann, G., Durndell, A., Macleod, H., & Glissov, P. (1988). Stereotyping in relation to the gender gap in participation in computing. *Educational Research*, *30*(2), 98-103.

Finally, a study on gender stereotyping about computer involvement suggests a change in the often-documented tendency of females to perceive participation in technology as unfeminine and to consequently avoid the use of computers for that reason. Nearly 1,000 university students in Scotland were asked to read a two-paragraph description of a computer science student and then to rate the student (1-5) on 16 attributes such as Well Adjusted, Fun to be With, and Aggressive. Half of the students were given the paragraphs with the computer science person a male; the other half a female. In general, the computer science student (regardless of gender) was rated more highly as ambitious, analytical, competitive, independent, well adjusted, self-reliant, and serious, than as introverted, aggressive, or bossy. In addition, the female computer science person was rated significantly higher than the male computer science person on all of the more positive attributes, and there were no significant differences between the ratings for the male and female on the more negative attributes. These results were consistent across male and female respondents both involved and noninvolved in computing courses. Whether this more favorable perception of females involved in technology holds in other settings, or whether it eventually leads to a higher rate of female involvement with technology, remains to be seen. However, the study is well done and encouraging for those interested in gender and its relationship to computer involvement. For more information, contact Macleod at the University of Edinburgh, Department of Psychology, George Square, Edinburgh, Scotland, EH8 9JZ.

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we look at a study comparing student performance on computer-managed arithmetic drill with performance on paper-and-pencil tests, and we abstract a summary of research on computer use in elementary education. Next, we look at three studies investigating uses of computers in schools that are identified as exemplary with respect to computer integration.

How Well Does CMI Manage Arithmetic Drill?

Hativa, N. (1988). CAI versus paper and pencil: Discrepancies in students' performance. *Instructional Science*, 17, 77-96.

This study involves nearly 300 children in grades 3-6, mostly in Israel but also in California. The California children were regular users of the Computer Curriculum Corporation (CCC) computer managed mathematics drill program, while the Israeli children used an adaptation of the CCC. An integral part of these CMI systems is the computer's management of student progress through levels of content-related difficulty. Mastery at a level allows the child to progress to the next level; failing to meet a certain percentage-correct criterion means the child is automatically moved to the next lower level. The educational logic behind this approach to management is well known and these particular drill materials are based on careful analysis of hierarchies of difficulties in elementary arithmetic procedures.

Hativa generated paper-and-pencil tests for each child, centered on where the CMI system indicated the child should be placed, but including a range of problems below and above the CMI-prescribed level. The children generally went farther, correctly, on paper-and-pencil tests than the level they were assigned by the CMI system. For example, most children went an average of 7.4 levels correctly beyond their CMI levels in addition. The ten children who did not worked at the same level in both media. The level difference was most pronounced for children defined as low-achieving, based on their ongoing computer-work scores. On the average, these students could do work 13 levels higher when the problems were given in paper-and-pencil form than when the same problems were presented by software.

Why these discrepancies? Hativa thoughtfully analyzes the software design and identifies various instructional decisions which may be retarding students' progress. At a fundamental level this cautions us against optimistic assumptions that CMI can be used to make valid and sensitive decisions about student management, even given a well defined area like addition, and extensively researched materials such as those of the CCC and its Israeli counterpart. As with Hativa's previous work, I strongly recommend this study.

US and British Research on Computers and Elementary Education: Similar Conclusions

Govier, H. (1988). *Microcomputers in primary education: A survey of recent research* (Occasional Paper ITE/28a/88). Lancaster, UK: Economics and Social Research Council.

I usually review specific studies in "Research Windows." However, Govier's research summary is especially well done and of particular interest to readers concerned with research results from different countries. Govier summarizes a wide variety of both American and British research relative to computer use in elementary schools (primary education for the British), provides an extensive annotated bibliography, and observes various trends appearing in both countries. She notes that group- or paired-student work at computers appears to be superior to individual work, even for a drill.

The impact of computer drills appears strongest within the first few weeks the drill is used, "suggesting the most important factor in determining the effectiveness of drill and practice is variety, and that . . . perhaps the micro might better be put to work as a manager of learning, setting varied assignments, rather than tying up this scarce resource for practice activities which can be carried out just as effectively using cheaper methods."

Logo research is carefully summarized by noting that Logo does appear to have effects on collaborative and communicative skills, but its effects on learning and problem solving are "more elusive." Govier does identify one trend: in most of the studies where Logo was found to have beneficial effects on learning, the learning was carefully structured by the teacher. "It appears that Logo skills only generalize when Logo is taught in a way which emphasizes the skills to be learned and encourages children to deliberately look for connections with other work . . . the discovery learning advocated by Papert is too unfocussed for transfer of learning to occur . . . a structured curriculum is essential."

Govier's summaries highlight over and over the importance of the teacher in any computer impact. I recommend this study to anyone wanting a current and thoughtful summary of research activity in the impact of computers on elementary-age children. Write for information about the paper (or for similar research summ[illegible]s on secondary level and policy makers) to the ESRC-ITE Programme, Department of Psychology, University of Lancaster, Lancaster, LA1 4YF, UK; or via BITNET, PSG001%UK.AC.LANCS.VAX1@AC.UK

State of the Art

Beaver, J.F. (1988). A national search for quality: An examination of high-quality elementary school instructional computing programs. Unpublished doctoral dissertation, Michigan State University.

In this study 51 U.S. elementary schools identified as having "high quality computing programs" were surveyed. The schools varied considerably in resources, size, amount of time involved with computers, and other variables. However, trends from the data show interesting patterns. Some highlights: Most of the schools located their computers in both a lab and in individual classrooms. Word processing was seen as the most important computer use, although keyboarding was not seen as of much importance: Drill practice occurred more often. In more than a quarter of the schools a "computer enthusiast" teacher made the planning decisions about computer use without consultation, while in an additional 20% of the schools, the computer enthusiast teacher was involved in decision making with the principal or a committee. An average of more than 300 "people hours" had been spent on planning for computer use in the schools. Only about 14% of total computer use related to programming (9% to Logo and 5% to BASIC), and virtually no time was given to databases and spreadsheets.

Survey responses indicated staff training and teacher willingness to change are critically important. This is particularly interesting in light of the actual per-student expenses on staff development. Even in these exemplary schools, the median per-student amount spent on staff development in 1987 was $0.00! Most money is still being spent on hardware, despite the acknowledged importance of teacher support and development. For more information about this 188-page report, contact Beaver at Elementary Education Department, SUNY College at Buffalo, 1300 Elmwood Ave., Buffalo, NY 14222.

Rose-Colored Glasses?

Mathinos, D.A., & Woodward, A. (1987, April). *The status of instructional computing in an elementary school: Removing those rose-colored glasses.* Paper presented at the annual general meeting of the American Educational Research Association, Washington, DC.

We are all familiar with survey data telling us how widespread computer use is becoming in schools. The conclusions about usage are frequently based on one or two sources: the quantity of machines available, and teachers' self-reports as to how often they or their students use the machines. The researchers in this study decided to look more carefully at a particular upper elementary school where computer use appeared to be exemplary. The school owned a total of 25 computers, 12 in a lab and the others distributed in classrooms; maintained a large, well-organized software library; had a building computer coordinator and a computer lab aide; was located in a district with extensive computer-related inservice; and was in the final year of a five-year district-wide instructional computing plan designed to integrate computer use into the curriculum.

Teachers responding to a questionnaire estimated their students used computers 6.5 hours per week in class and 2 hours per week in the lab. But even so, limited hardware availability was continually criticized. The teachers were also asked to keep daily logs of computer use over a 13-week period and to allow regular classroom observations to occur.

A strong discrepancy was found between potential and practice. A typical class used computers only 45 minutes per week. Only 40% of the children used the computer at all during the 13-week observation period, and half of these only used a computer once during this period. When computers were used, there was little evidence that computer use was integrated into instruction or individualized for different students. Children were often allowed free choice of software as a reward for finishing work, and nearly half the student computer use during the 13 weeks appeared to be of game or electronic magazine software in this context. Although lack of hardware was frequently mentioned, there were "at least five computers sitting unused, yet available and accessible, on any given day."

What are the implications of this study? I think it reinforces the complexity of the implementation problem. Even given good resources and support, do we begin to exploit the potential of the computer? Is the answer to obtain more hardware? How many of our schools does this usage picture describe? For more information, contact the authors at the Graduate School of Education and Human Development, University of Rochester, NY 14627.

Are Computers Changing Curriculum?

Plomp, T., Steerneman, A., & Pelgrum, W.J. (1988, July). *Curricular changes as a consequence of computer use.* Paper presented at the European Conference on Computers in Education, Lausanne, Switzerland.

As in the previous two studies, these researchers located schools with a reputation of being leaders in educational computing. This time the schools were in The Netherlands. As before, all had computer labs, extra hardware, computer coordinators, and extensive inservice opportunities. In one school the decision was made to restrict the use of computers to remedial teaching outside normal classes. In the others, there was integration within the regular classroom. The researchers found no evidence that computer use was making any change in the curriculum. Students were being evaluated as they had been prior to introduction of the computers. The only changes that seemed to be occurring were in the more frequent use of group or paired-student work, and in the occasional use of different classrooms. The authors reported, "none of the schools has a clear educational vision of what they would like to achieve with the new technologies: the statements of their objectives are vague, there is no written policy presenting 'leading ideas' which may structure activities at the school level." For more information, contact the authors at the Department of Education, University of Twente, Postbus 217, 7500 AE Enschede, The Netherlands.

What should we conclude from these three investigations of "exemplary" schools? Until we have real, regular integration of computer use in ongoing instruction we cannot expect to see much meaningful change in students, teachers, or curriculum. Fostering this type of computer use is apparently very difficult, and we must not be overly complacent about the value of computer use in our schools just because some kind of use is going on.

[Betty Collis, Department of Education, University of Twente, Postbus 217, 7500 AE Enschede, The Netherlands.]

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we concentrate on studies relating to interactive video, sometimes with and sometimes without computer support. We summarize four interesting studies and include a reference list with the names of additional sources of information about research into the use of interactive video in the classroom setting.

Videodisc as a Teacher's Tool

Carnine, D., Englemann, S., Hofmeister, A., & Kelly, B. (1987). Videodisc instruction in fractions. *Focus on Learning Problems in Mathematics*, 9(1), 31-52.

This study presents an excellent example of the care with which instructional materials should be developed, with or without the expectation of the involvement of technological support. The authors analyzed children's difficulties with fractions in a very thorough and perceptive fashion and developed a videodisc with many animated visual sequences making use of video highlighting, sound effects, and other techniques, all designed to anticipate and remediate common student misconceptions about fractional operations. The interactive aspects of the software accompanying the videodisc are designed to be used by the teacher, not by the student, so that the teacher, not the computer, makes the ongoing diagnoses of student errors and needs during each of the ten lessons supported videodisc. Children look at the videodisc together, in a whole-class setting, under the guidance of the teacher. In addition to the videodisc and software, teachers were supplied with specific strategies for integrating the interactive videodisc into an entire instructional sequence on fractions. Tests of student performance compared to groups without the videodisc materials show significant gains.

I think this is an important study, because it describes a valuable use of computer-supported materials by the teacher in the whole-class setting. Rather than trying to create software with which children would interact independently and which in itself could provide an ongoing assessment of student needs and difficulties, the software tool is specificaly designed to support the teacher's already developed expertise in these areas. Instructions as to where to go on the videodisc for remediation of various sorts of student misconceptions appears to be well designed, as the teachers indicated it to be easy to use and helpful. In particular I like the consideration given to integrating and managing the use of the videodisc in the context of a complete lesson. Finally I recommend the care with which the researchers analyzed student misconceptions with fractions prior to the development of the videodisc sequences as a model of the sort of contribution educators should be making to courseware design. Write to Carnine, Engelmann, and Kelly at the University of Oregon, Eugene, Oregon 97403, or Hofmeister at Utah State University, Logan, UT 84322 for more information.

Monitoring the Fraction Videodisc in Naturalistic Settings

Kelly, B., Gersten, R., & Woodward, J. (in press). Research on teachers' implementation of an interactive videodisc curriculum. In T. Grady (Ed.), *Technology and curriculum*. Alexandria, VA: ASCD.

In the previous study the researchers described the development and initial testing of curriculum materials including an interactive videodisc for the teaching of fractions. During their development work they interacted frequently with teachers involved in using the materials. In this study they examined the use of the materials by teachers in more natural conditions, keeping in mind "the reality principle" (I like this): the importance of developing a feasible classroom intervention that did not require busy teachers to radically reorganize their teaching styles or methods of classroom management, or to seek external assistance. The researchers approached nine teachers who indicated they were frustrated with their students' progress with fractions. These teachers were asked to try out the videodisc materials. Eight teachers agreed to participate and were given an amount of inservice training parallel to that "generally provided by publishers of standard print curricula" (two one-hour inservice sessions). Teachers were also provided with recommendations for classroom implementation and a demonstration of how to operate the videodisc equipment. The teachers were observed before, during, and after their use of the videodisc materials.

The results were very good. Teachers indicated little difficulty in using the materials, generally used them as recommended, found the interface for the interactive videodisc easy to manipulate, and appreciated that the videodisc graphics could "visually demonstrate relationships and concepts so much more elegantly, with so many more examples, and so much more quickly than they (the teachers) could." Teachers in no way felt the videodisc was "replacing them" but stressed the importance of the teacher factor in making instructional decisions relating to the use of the interactive video. They particularly appreciated the carefully done teacher support materials giving strategies for using the videodisc in the whole-class setting under teacher guidance. I recommend the "reality principle" as well as the work of these authors very highly. Write to them at the University of Oregon, Eugene, OR 97403, for more information.

More on Teachers and Videodiscs

Mably, C. (1987). Interactive video as a school resource: Rolls Royce or Model T Ford? In D. Laurillard (Ed.), *Interactive media: Working methods and practical applications* (pp. 191-204). Chichester, West Sussex, UK: Ellis Horwood Limited.

As in the last study, Mably describes an investigation of teachers who were given unlimited access to an interactive videodisc. In Mably's study the teachers were also primary school teachers but instead of being given a computer-supported interactive video system, they were provided with a

"Level 1 interactive video system" without computer support or rapid access to locations on the vieodisc. The teacher or student used a direct entry method of indicating the starting and ending points of a desired sequence of frames. Despite the manual entry of frame ranges with this type of inexpensive video, many of the same characteristics of interactive videodisc—rapid access, still frames, page scans, fast/slow motion, repeat memory, and multiple audio trails—were still available. The material on the videodisc consisted of three educational television broadcasts on science, each organized in a linear fashion arranged in chapters but with an indexed reference section. Given this relativley inexpensive system (a "Model T" version), the teacher found excellent teaching opportunities. After classroom experimentation, each of the participating teachers commented positively about both the pedagogical and implementation-related aspects of the use of the materials.

The author goes on to make many interesting points about the potential of "Model T" interactive video, including its use as a "stepping stone" to eventual teacher use of computer assisted interactive video. One idea I find particularly interesting is that of having dual sound tracks with the same video images. For example, one track could be for the students, and another for the teacher. This suggests a new tool for inservice activities. Other good ideas for interactive videos using existing educational broadcast materials are also given. For more information I recommend the entire book from which this article is taken. Write to the publisher at Ellis Horwood Limited, Market Cross House, Cooper Street, Chichester, West Sussex, England, or to Dr. Laurillard, the editor, at the Institute of Educational Technology, The Open University, Milton Keynes, England.

Interactive Videodisc as Stand-Alone Instruction

Bunderson, C. V., Baillio, B., Olsen, J. B., Lipson, J. & Fisher, K. M. (1984). Instructional effectiveness of an intelligent videodisc in biology. *Machine-Mediated Learning*, *1*(2), 175-215.

Although this study is from 1984, it is not dated and offers another very good model of the care which should go into the design, testing, and revision of interactive videodisc learning materials. Unlike the materials described in the previous three studies, Bunderson and his colleagues designed materials to serve as stand-alone instructional delivery systems for university students studying living things in biology courses. The article begins with a thorough consideration of different issues underlying the design of machine-mediated instruction and from this moves to a summary of six years' worth of development and evaluation of various phases of the WICAT videodisc, *The Development of Living Things*. In each of the evaluation studies, students using only the videodisc were compared with students receiving conventional instruction in topics addressed by the 108,000 images organized on the videodisc. Videodisc-using students consistently did better than traditional-instruction students on posttests, and in addition spent significantly less time learning the material. The studies also provide some interesting insights on approaches used by the students as they worked through the lessons—for example, five different patterns of student movement through the videodisc content are described, and students made relatively little use of some of the available student options for accessing the videodisc. For more information, contact the first four authors at WICAT Systems, Inc., Box 539, 1875 South State Street, Orem, Utah 84057. For information on obtaining an "executive summary videodisc" of the project, contact Dr. Bunderson directly.

Additional Resources

Instead of summarizing a fifth study this month, I would like to recommend a selection of articles for those interested in learning more about interactive video as an educational tool.

1. Hannafin, M.J. (1985). Empirical issues in the study of computer-assisted interactive video. *Educational Communication and Technology Journal*, *33*(4), 235-247.

A good review of research related to components of interactive video, accompanied by a comparison of various other technologies such as instructional video and instructional television, and concluding with an interesting series of questions for further research.

2. DeBloois, M. (1984). *Effectiveness of interactive videodisc training: A comprehensive review.* Falls Church, VA: The Monitor Report Series, Future Systems, Inc. (80 pp.). Available as ERIC Document ED 278 370.

This study includes an extensive and well summarized literature review of both conceptual articles and experimental studies about applications of interactive videodiscs. Of particular interest is a well documented chapter related to adult learners using this medium.

3. Hofmeister, A. M., & Englemann, S. (1985, April). *Designing videodisc-based courseware for the high school.* Paper presented at the annual meeting of the American Educational Research Association, Chicago). (See the papers by these authors earlier in this column for their addresses.)

Another good description of the development and evaluation of interactive video materials—both with and without computer support—this time for topics in secondary school mathematics and science. The authors identify many important educational considerations during the design, development and fieldtesting stages.

4. Smith, E. E. (1987). Interactive video: An examination of use and effectiveness. *Journal of Instructional Development*, *10*(2), 2-10.

An extensive and up-to-date bibliography accompanies this well written article which presents an overview of issues and research results relative to the use of interactive video in education and training.

5. Nave, G., & Zembrosky-Barkin, P. (1985). *Interactive video in special and general education: A development manual.* Eugene, OR: ICCE Publications.

This 68-page manual available from ICCE describes in helpful detail a 17-step sequence for the development of interactive video courseware. The steps are illustrated by their application in the development of courseware on life enhancement skills for secondary-aged handicapped students.

6. Johnson, V. M. (November/December 1987). Evaluating interactive video. *Interactive Update*, pp. 8-10.

A thorough collection of criteria for the evaluation of computer-augmented interactive video, categorized around the headings, "The Program Structure," "The Program in Use," "Technical Aspects," and "Costs and Benefits." The author is an instructor of Educational Technology at the University of Maiduguri, Nigeria.

RESEARCH WINDOWS

Betty Collis

In this month's "Research Windows" we look at word processing from an implementation perspective; gender and cooperative learning strategies with interactive video: variations of pretests within mastery learning software; and a comparison of face-to-face and electronic mail environments for peer comments on writing. We also briefly cite some additional research associated with similar topics.

Implementing Word Processing

Dalton, B.M., Morocco, C.C., & Neale, A.E. (1988, April). *"I've lost my story!" Mastering the machine skills for word processing.* Pager presented at the Annual Meeting of the American Educational Research Association, New Orleans.

In this highly useful research, four 4th-grade classes were extensively involved in the use of word processing for writing, with each child using the computer for two to three periods per week from November to May. All of their teachers used a process approach to writing and were considered excellent teachers by their school systems. Data were collected on teacher and student behaviors during the computer augmented writing sessions throughout this period.

Regardless of how the teachers approached the teaching of word processing skills, or how much they tried to focus on writing skills, using the word processor itself remained a major preoccupation for students throughout the year. For example, teachers' time spent on teaching or helping students with word processing mechanics compared to writing remained about the same in April as it had been in January. The researchers note that so much time had to be continually given to troubleshooting word processing problems that "relatively little time" was left to focus on "the process and content of students' actual writing." File management created persistent difficulties, probably because the children lacked a conceptual understanding of what happened to their writing after they typed it. The article discusses other implementation difficulties and concludes with excellent strategies for integrating writing objectives with machine skills in ways that relate clearly to the reduction of these difficulties.

This is a type of research study that I especially endorse—one that blends theory and practice. I recommend it to any teacher intending to incorporate the use of word processing into the development of students' writing skills, regardless of the students' age. To obtain the study write to the authors at "The Writing Process;" Educational Development Center, Inc., 55 Chapel Street; Newton, Massachusetts 02160.

The following study also relates to teaching the mechanics of word processing and suggests another approach that can help give teachers more time to focus on writing, instead of software use.

Cortese, J.G. (1988). *Testing two methods of instruction to successfully execute introductory steps of* WordPerfect. Unpublished report, Montana College of Mineral Science and Technology.

Ms. Cortese also was concerned with the amount of time required of writing teachers to deal with word processing mechanics. She worked with teachers of older students and developed an audio tape tutorial which she subsequently showed to be as effective as teacher-intensive instruction. For information about her materials, write to her at the college named above, Butte, Montana 59701.

Cooperative Learning As a Computer-Use Strategy

Dalton, D.W. (1988, April). *The effects of cooperative learning strategies on achievement and attitudes during interactive video.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

This study focused on a variety of different ways that students can use an interactive video. The students were 98 fifth-and sixth-graders who worked with interactive video in which the pacing of lesson presentation was either learner controlled or computer controlled. In addition, students had to work cooperatively in either same-sex or mixed-sex groups.

Overall, students with learner control outperformed computer controlled students on a posttest, a result consistent with other research. This study makes special a contribution in going beyond a conglomerate result to investigate learning more closely. For example, when an "instructional efficiency" ratio was calculated, dividing achievement score by time spent on the lesson, there was no difference between the groups. This suggests that it might be the additional time involved when students can control the pace of a program that is the critical aspect rather than the interaction itself.

Also valuable was an investigation of the types of interactions students engaged in when using the materials. The additional time available in learner-control cooperative learning was often used for increased off-task behavior compared to the computer-controlled situation, a finding that suggests to us that providing interactive, cooperative situations in itself may not always result in a better learning experience.

Finally, significant differences were found in the behaviors of male-male, male-female, and female-female pairs, particularly in that male pairs tended to hurry through interaction, turning it into a competitive activity relative to neighboring groups, and often showing difficulty in cooperating or taking turns. The conclusion of this is that boys may need more explicit instruction in cooperative behavior in order to prevent them from speeding impulsively through a computer-use experience. For more information, write to the researcher at the Center for Educational Technology, Florida State University, Tallahassee, FL 32306.

The following study also focuses on cooperative problem-solving, this time using transcripts of dialogues between 72 pairs of 10-12 year old students engaged in cooperative problem solving tasks.

Erkens, G., & Barnard, Y.F. (1988, April). *Computer simulation of information exchange during cooperative problem solving*. Paper presented at the annual meeting at the American Educational Research Association, New Orleans.

Erkens and Barnard give a careful analysis of students' verbal interchanges in order to build a model of problem solving and information exchange and to develop simulation programs that model students in such interactions, the goal of the research is to build an "intelligent" program with which the student can interact on new problem solving tasks where interaction is required. For more information, write to the researchers at the Department of Educational Research, University of Utrecht, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands.

Pretests and Computer-Based Mastery Learning

Dalton, D.W., Goodrum, D.A., & Olson, J.R. (1988, April). *The effects of computer-based mastery pretests on learner achievement and motivation*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

In this study 120 fifth-and sixth-grade students used tutorial software to learn new content (divisibility rules). The only differences in their experiences were that some were first given a 20-item timed pretest; others took the same pretest, but with the pretest ending as soon as the student got five wrong; and others had no pretest at all. Students were given a mastery posttest and a "motivation scale" after the lessons on the computer were finished.

No gender differences were found; however, learners who had to work through the entire pretest first did less well and were less motivated than the other students. The authors conclude that students often got frustrated doing pretest questions which they did not understand, and did not understand the role of a pretest as a diagnostic tool. Being able to exit early from a frustrating experience appeared to have better results. The authors make a number of other useful comments about the design of pretests for computer-based instruction. Write to Dalton at the address given earlier in this column for more information about this study.

Face-to-Face versus Electronic Mail for Peer Responses

Stroble, E.J. (1988, April). *A look at writers' comments shared on computer screens: Can electronic mail facilitate peer group response?* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

What are the advantages and disadvantages of having students contribute peer response and suggestions about each others' writing in face-to-face group discussions compared to electronic mail? In this study 20 student teachers participated in both types of communication. Although there were some variations, writers received equal numbers of comments in the two modes of communicating, apparently made similar use of advice given in both modes, and generated final compositions of comparable quality. The author sees this as promising support for the use of telecommunications as an instructional tool, particularly in situations where it is difficult for students to be present at one time and in one place, or for students who prefer to construct a written response rather than engage in oral commentary. However, the study points out some potential difficulties of electronic messaging in this context: "Simultaneous threads of discourse" must be unraveled and a moderator should occasionally intervene to summarize the flow of the discussion and to prompt more participation. The study gives some useful strategies for these types of interventions. For more information, write to the author at Northern Arizona University, Flagstaff, AZ 86011.

RESEARCH WINDOWS

Betty Collis

In this month's Research Windows we discuss three studies dealing with various characteristics and effects of educational software, a study relating to the implementation of curriculum materials, and a study of user mistakes when interacting with databases.

Color as a Significant Variable

Hativa, N., & Teper, A. (1988). Differential effectiveness of three color treatments in learning geometric concepts via computer-guided teaching. *Journal of Educational Computing Research*, 4(3), 303-320.

Judging from the consistency with which color is used in educational software, there appears to be a belief that color has a positive effect on at least motivation but possibly also on learning. Hativa and Teper survey the research that has been done on the use of color in educational media other than computers—surprisingly little has been done specifically on the use of color in educational software—and from the results of these previous studies hypothesized that purposeful use of color for cueing would increase learning more than the indiscriminate use of color or the omission of color, and that this effect would be strongest for low-ability students. They also hypothesized that students would have more positive attitudes toward learning with color than without.

To test these hypotheses, a well designed study was conducted. Computer-guided teaching—a method in which the computer serves as an "electronic chalkboard" to present questions, animate demonstrations, and show real-life applications—was used in each of three groups. The software was used in whole-class settings, with the same teacher following the same script in each of the classes. The script was for a 40-minute lesson on special parallelograms. The only thing that differed in the lessons was the use of color in the software. One treatment involved six colors used for purposeful cueing, such as for indicating opposite sides in the parallelograms. The second treatment used the same six colors but without any meaning relative to the content. The third group used the same software but only in a monochrome version. One hundred and nine students from four heterogenous ninth-grade classes in a suburban Israeli secondary school were randomly assigned to the three groups. Great care was taken to anticipate the possible confounds that could influence the study.

The results supported the hypotheses. In addition, all students gained a significant amount of geometric understanding after only the 40-minute lesson with a single computer used in the whole-class setting, and retained their understanding when given a retention test a month later. However, the purposeful color group did significantly better than either of the other two groups on both the immediate test and the pretest. Also, as predicted, it was the lower-ability students who benefitted most. Also, students had more positive attitudes about learning from software with color than without. I recommend this study, both as a model of excellent design and science and as a practical contribution to our knowledge about significant variables that affect the impact of computer use in education. For more information, contact Dr. Hativa at the School of Education, Tel Aviv University, Tel Aviv, 69978, Israel.

Perceived and Actual Effectiveness of Software

Jolicoeur, K., & Berger, D.E. (1988). Implementing educational software and evaluating its educational effectiveness: Part II. *Educational Technology*, 28(10), 13-19.

Surprisingly few studies compare the effect of different commercially available software packages on student learning and retention. In this interesting study, 430 fifth-grade students from eight Southern California schools used one of four different spelling programs and one of four different fraction programs during a four-week period. The spelling packages—two of which were games and two of which were tutorials—each involved the same set of spelling words, words that were not otherwise being drilled in the children's classrooms. The fraction programs—also two games and two tutorials—supplemented classroom work in fractions. Half the students used the spelling programs during the first two weeks and then the fraction programs for the second two weeks. The order was reversed for the other half of the students. Students were pretested prior to any use of the software, and at the end of Week 2, on basic fraction concepts and on the spelling words. A retention test was administered after the computer use finished.

At the end of Week 2, as expected, students using the spelling software did better on the spelling test than students who were not using it, and students using the fraction software did significantly better on the fraction test than students not using the fraction software. Thus, overall, the software contributed to student learning. However, the effectiveness of the various packages varied widely. SVE *Fractions*, a tutorial, was by far the most effective fraction software, followed by EduWare *Fractions*, also a tutorial. The Davidson *Spell It!* tutorial was the most effective spelling program, followed by the *Spell It!* game. There was generally no difference between tutorials and games in overall effect on learning. There were no gender differences in learning, in attitude toward the learning value of the software, or in effects related to the fraction software. Girls, however, rated the spelling software more positively than did the boys. The teachers and students were asked to rate the software based on what they perceived its educational value to be, and this generated one of the most interesting results of the study. Neither students or teachers were able to judge the educational impact of the software after four week's use. For example, teachers gave the most effective spelling program the lowest effectiveness rating, and the correlation between students' learning and students' ranking of how much they thought they learned from particular programs was virtually zero. The authors feel this implies that "students should not be left on their own to determine the order and parts of a software program they will use" (p. 18). For more information, write to Dr. Jolicoeur at Lehrer Associates, 4208 Dundee Drive, Los Angeles, 90027.

Strategies for Curriculum Integration

van den Akker, J. J. (1988). The teacher as learner in curriculum implementation. *Journal of Curriculum Studies, 20*(1), 47-55.

This study deals with a comparison of strategies that help teachers implement innovative practices in their classrooms. It begins with a careful examination of the teacher as learner, particularly in the context of learning to implement innovative educational materials in the way they were intended to be used by their developers. Two different strategies were tried. In one, the teacher support materials focused on guidance for the teacher's actions with specific ideas for delivering a lesson. Possible implementation and managerial problems that the teacher might encounter during the lesson were described and strategies given for avoiding or minimizing. A second set of teacher support materials focused much less on specific practical guidance but instead gave the teacher a broad variety of background information and ideas for classroom activities.

A sample of 40 teacher volunteers was randomly divided into a group using the "implementation" materials and another using the "ideas" materials Teachers in both groups spent about the same amount of time preparing for their lessons (involving innovative aspects of using discovery learning in science classes); however, the implementation materials group taught their lessons "much more in accord with the intentions of the curriculum developers," particularly with respect to "creating and maintaining the intended inquiry approach throughout the lesson." Teachers in the other group often "lost their grip on the stream of events and were overwhelmed by them, or restricted themselves to handling organizational problems and assumed a more withdrawn attitude" (p. 53). Students in the implementation group spent 50% more time on task than students in the group whose teachers did not have implementation guidance in their lesson materials. Most interestingly, the "non-implementation" teachers adapted the lessons to their own routines, while teachers in the implementation groups adapted their own roles to the intentions of the innovative models.

This study does not in itself deal specifically with computer use. However, the same team of researchers has done replications of the approach in the context of support materials for innovative uses of computers in education and have had similar results. I recommend this article because the computer-specific study is not yet available in published form. The work is carefully developed in the context of curriculum theory and practice. For more information about the approach to support materials development, contact the author at the University of Twente, Department of Education, Postbus 217, 7500 AE Enschede, The Netherlands.

Interactive Fiction for Reluctant Readers

Lancy, D. F., & Hayes, B. L. (1988). Interactive fiction and the reluctant reader. *English Journal*, November, 42-46.

Interactive reading software has various characteristics. Its users must explore some territory that they read about on the computer; keep track of various items and clues encountered; use problem solving skills; and interact with the software, either through multiple choice options or by entering commands that must be spelled correctly and that must respect a limited syntactical environment. Mainly, however, interactive reading software requires the student to do a considerable amount of careful reading. Lancy and Hayes note that the average fifth-grade child reads books for four minutes or less per day, and conducted an exploratory study to see if children below this average in terms of interest in reading would use interactive reading software and thus participate in some form of reading activity for significantly longer periods of times than they would otherwise spend on reading. They worked with eight children, grades 5 to 9, for three hours a day over four weeks. As hypothesized, they found that these reluctant readers were "deeply engrossed" in using their programs, making no complaint about the considerable amount of reading that they had to do in order to use the software. The authors add some useful suggestions for incorporating interactive reading software into reading time in school and also give a list of 25 interactive fiction packages which have been attractive to children and tested in the school setting. For more information, contact the authors at Utah State University, Logan, Utah, 84322. (Dr. Lancy is currently at the Faculty of Education, UWI, St. Augustine, Trinidad, West Indies.)

Natural Language Queries and Databases

Reilly, R., & MacAogain, E. (1988). Poorly formed input and miscommunication in natural-language keyboard dialogue. An exploratory study. *Computers in Human Behavior, 4*, 275-283.

What sorts of errors or miscommunications do users make when given the opportunity to interact with a database when they can use natural language queries? In this study, 21 adults, all efficient typists, were observed over ten hours as they interacted with a database program to do some particular tasks. All of their inputs were retained by the software for subsequent analysis. They could use natural language to enter their instructions. Four hundred seventy-six "utterances" were entered during the study. The median utterance length was 10 words. Ill-formed utterances included many misspellings (186 in 134 of the utterances), and "extra grammaticalities," (missing words, spurious words, out of order words) appeared in 40% of the input. The missing word types include errors such as "Copy new files my directory." Spurious word examples included, "Copy if you would be so kind the new files to my directory please." Word order errors were of the nature, "New files to my directory copy." The users apparently "expect the computer to be able to cope with telegraphic input" (p. 281). Such insights make this study helpful to those who will be teaching students about database query and usage. The first author can be contacted at the Educational Research Center, St. Patrick's College, Dublin 9, Republic of Ireland.

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RESEARCH WINDOWS

Betty Collis

This month's studies cover a variety of interesting focuses: word processing, CAI. Logo. problem solving with computers. and learner control in CAI. Each contributes a valuable perspective. As a set. the studies are particularly good examples of thoughtful and productive research strategies.

Does the "Look" of Word Processed Text Influence Marks?

Peacock. M. (1988). Handwriting versus word processed print: An investigation into teachers' grading of English language and literature essay work at age 16+. *Journal of Computer Assisted Learning*. 4. 162-172.

This is a fascinating study. It addresses the extent to which the subjective impact of word processed print can influence grades teachers assign to the text.

In England, senior students submit essays to national grading boards on standardized topics. Some of these are general language-use essays, others are essays on specific works of literature. These essays are graded on a scale of 1 (top) to 5 by a team of trained examiners. In this study, eight essays were chosen from this collection, four representing work graded as very good ("1" or "2") and four representing papers graded as weak ("4"). Half were language, half were literature essays. A total of 411 experienced teachers, participating in various conferences, were asked to read the eight essays and grade them (the grades given by the examining team were not indicated on the essays). All the teachers were familiar with the five-point scale. The interesting thing is that half of the 411 teachers were given photocopies of the original handwritten essays, the other half were given the same essays, but in print (word processed) form. No corrections of spelling, grammar, or punctuation occurred.

The results are clear—teachers assigned higher grades to the essays in print form than they did to the same essays in handwritten form. This was particularly true for the language essays originally graded as weak ("4"). Only 10% and 1% of the teachers reacting to the handwritten versions of these essays upgraded them to "3," but 50% and 20% of those responded to the printed versions gave them "3." Overall, average marks went up a whole grade when teachers reacted to the word processed copies, with the exception of the essays already at the "1" level, which stayed at the "1" level.

There can be two ways to interpret this—perhaps word processing frees teachers from details of presentation so that they can better see the "true" worth of the writing, or that teachers are perhaps too easily influenced by appearances. In either case, word processing is to the students' advantage! For more information, write Mr. Peacock at TVEI Evaluation Unit, School of Education, University of Leeds, LS2 9JT, UK.

Differential Effectiveness of CAI

Hativa, N. (1988). Computer-based drill and practice in arithmetic: Widening the gap between high- and low-achieving students. *American Educational Research Journal*. 25(3). 366-397.

I have reported earlier about a similar study by Hativa, but her work is so useful that it is worth noting a new and accessible report by her that has recently come out.

Hativa and her colleagues closely observed seven children using CAI mathematics drill and practice, operating under a sophisticated management system during approximately 40 sessions of interactions. She presents her analysis in carefully done case study form. (Her methods, I believe, can serve as a model for this type of research relating to computers in education.) What she explores is the premise, often cited in research summaries, that drill and practice on computers is particularly helpful for low-achieving students. She found the opposite. In this study she tries to better understand the processes that make work with the CAI system more effective for the capable students and relatively less effective for the weaker students.

She found that the able students displayed various qualities, unrelated to mathematics as such, that the less able students did not display to nearly the same degree. These included good memory, ability to learn from mistakes, aggressiveness in asking for help, and persistence. In contrast, the lower-achieving students were much more likely to make "child-machine" errors (pressing the wrong key even while saying the correct answer; pressing a key too heavily, resulting in the repetition of a digit, etc.). Both groups of students did about the same amount of practice per session, and both groups had about the same error rate on the first new problem in a level. The difference in subsequent success rate seemed highly related to the reasons mentioned above, reasons which can influence performance in computer use in general. Contrary to our usual expectations about CAI offering particular help to lower-ability students, it may in fact widen the gap between those with the flexibility to adapt to a new medium with already developed problem solving skills, and those with less of these attributes.

Hativa concludes that, given our current level of intelligent CAI, there will always be some students who benefit from a certain type of computer experience and others for whom the medium creates new difficulties. Her work highlights the value of looking "for relationships between different modes of operation of CAI systems and their effectiveness for students who differ in learning styles and aptitudes" (p. 395). Hativa's address is School of Education, Tel Aviv University, Tel Aviv 69978, Israel.

Logo and Cognition

Lehrer, R., Guckenberg, T., & Lee, O. (1988). Comparative study of the cognitive consequences of inquiry-based Logo instruction. *Journal of Educational Psychology*, *80*(4), 543-553.

It is now an old question: Does Logo contribute to the development of children's intellect? From the extensive research which has been done on this question, we know that any effect of Logo on thinking skills is strongly influenced by a number of critical variables, such as the instructional method used in conjunction with Logo experiences, and the "cultural climate" of the classroom. This study attempts to anticipate many of the problems often associated with interpreting the effects of Logo.

Forty-five third grade children were ranked on mathematical ability and then assigned to three instructional situations, two involving Logo and the third an attractive array of commercially available "problem solving" software. One of the Logo groups focused on programming strategies to solve graphics problems and the other on using Logo to solve geometry problems. Children, working in pairs, had 47 half-hour instructional sessions, built around a common instructional methodology based on "inquiry-based mediation." In all three groups, instructors presented problems, asked leading questions, helped children apply strategies appropriately, and generated counterexamples to "entrap" children's misconceptions. In addition, children had an average of 71 additional independent practice sessions at computers in their own classrooms during the seven months of the experiment. The same instructors rotated among all three groups.

Given all this care about the research setting, what was found? There was no evidence of a "learning to learn" phenomenon nor was there any difference between the three groups on a general problem solving task. However, children in the Logo groups "planned more effectively" and "represented the planning task differently" than did the control children. Logo participation in either group was seen as leading to increased understanding of geometry relative to the non-Logo children. However, "experience with Logo did not seem to alter children's conceptions of the role and nature of errors or to bring about other notable epistemological changes" (p. 542).

There are other interesting conclusions in this study. For more information contact the first author at the Department of Educational Psychology, University of Wisconsin, 1025 West Johnson Street, Madison, Wisconsin, 53706.

Are Students Really Problem Solving When They Use Problem Solving Software?

Safrit, M. J.; Ennis, C. D., & Magle, F. J. (1988). The use of problem solving skills in computer-aided instruction: An evaluation. *Journal of Computer Assisted Learning*, *4*, 227-243.

As we know, there are many pieces of software described as providing problem solving experiences for students. In addition, it has been frequently hoped or believed that students may develop better problem solving skills through computer activities. In this study the developers of software designed to require use of higher-order cognitive processing, or problem solving, from the user have taken considerable care to try to confirm the actual engagement of these sorts of thinking among students using the software. The study is very interesting and helpful in the way it first analyzes problem solving activity and then employs careful and innovative procedures to capture and analyze students' thinking processes as they use the software.

The conclusions are encouraging—the six undergraduate students who were involved in the study "frequently used explicit problem solving strategies to synthesize information" (p. 237) as they used the program. They also noted that three students consistently chose a problem solving strategy that involved making use of tables and tutorials that were available in the program while the other three students made little use of these support options, and when they did make use of them, made more errors than when they did not use them. This finding supports our growing awareness of the way individual differences interact with computer possibilities. Supplying extensive libraries of support material, a feature of some current programs, may not be a necessary or desirable feature for some learners. The researchers also found the strongest evidence of high-level thinking occurring during the students' first exposure to the program, even though situations in the program varied. This may suggest that figuring out the demands of the software was as much of a problem solving experience itself as is the substance of the program. I recommend this study because it shows a promising approach toward a procedure for evaluating claims or hopes about students, computer use, and higher-level thinking. Write to the first author at the School of Education, Department of Physical Education and Dance, 2000 Observatory Drive, Madison, Wisconsin, 53706.

Learner Control versus Program Control

Carrier, C. A., & Williams, M. D. (1988). A test of one learner-control strategy with students of differing levels of task persistence. *American Educational Research Journal*, *25* (2), 285-306.

The purpose of this study was to contribute to a better understanding of the conditions under which granting of learner control in a tutorial program will be beneficial to students. The authors begin by noting that previous research on learner control has yielded inconsistent results relative to its advantage over program-controlled pacing, sequence, or amount of practice. They suggest a more helpful model for understanding the situations in which learner control is beneficial involves the amount of material studied, relevant learner characteristics (particularly "task persistence"), types of learner decisions allowed, and psychological reaction to being given a choice.

To test some aspects of their model, 114 sixth-graders participated in an experiment.

Research Windows

All the students initially interacted with a computer tutorial on "propaganda techniques" used in advertising, in which they were allowed to select any quantity of practice or examples (full learner control). Based on their level of choice, they were placed into four groups relative to the tendency the user has to try various aspects of a program.

This tendency is described as "task persistence." I am not sure I agree with this label. However, within each of the four levels, students were randomly assigned to one of three versions of the remaining parts of the propaganda tutorial: full learner control, enforced exposure to all examples, or minimal exposure to examples.

The analyses of results are complicated and perhaps overextend what can be taken from one experiment; however, two outcomes are particularly interesting. Overall, learner control was more beneficial than program control, even when amount of material read was controlled for. Also, high- and low-persisting students performed more poorly than the medium persistence groups for the two program-control options.

This curvilinear result is interesting in that it suggests that viewing relatively more material can lead to inefficiency rather than benefit. In this study, this pattern was not sustained for students given the chance to make their own decisions about quantity of example material. The study is useful to those who wish a sophisticated examination of the learner control aspect; as we have seen in many other contexts, it supports the value of a certain computer option for some students but not necessarily for others. For more information, contact the first author at the College of Education, University of Minnesota, 104 Burton Hall, 178 Pillsbury Dr., SE, Minneapolis, MN 55455.

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RESEARCH WINDOWS

Research Retrospective: 1985-1989

by
Betty Collis

This column marks the end of my fourth year of writing "Research Windows." Instead of my usual format—summarizing individual studies—I have decided this month to look back over the four years and 180 studies I have reviewed, with the idea of identifying trends and messages. I will consider the studies in various groupings before concluding with some overall comments. The groupings are somewhat arbitrary, as many studies could be classified in more than one way.

I use a code to refer to the studies: Year/Month/Position in column. For example, 86/3/2 means the second study reported in the March 1986 issue. 87/8-9/3 means the third study reported in the August-September 1987 issue, and 87-88/12-1/4 means the fourth study mentioned in the December-January, 1987-1988 issue. The reference section lists all the studies under a particular heading. I have placed an asterisk (*) next to studies I think are particularly interesting.

Curriculum-Related Instructional Support

Language Arts

Within this category, the largest single group relates to word processing (15 studies—see (1) in the references for a listing). The major trends are that students like word processing, they like writing better with word processing than by hand, and even young children can be effective users of word processing. However, it is also clear that students are not likely to make effective use of word processing without explicit instruction about revision away from the computer. More generally, the impact of word processing is strongly dependent on the teacher. In terms of practical application, the study coded 89/3/1 is an excellent example of how research can help teachers make better use of word processing in the classroom.

Four studies relate to keyboarding (2). Their general conclusion: that even young children can acquire functional keyboarding skills, sometimes only through regular computer use, not formal instruction. However, such skills can fade quickly without practice. Three studies examined the "Writing to Read" system (3) and found good impact on at least some aspects of writing, no particular improvement on usual reading achievement, and some points of criticism of the overall system. One study (4) was particularly interesting in that it noted the many new vocabulary words that occur in the context of using educational software but that are not yet systematically included in traditional reading word lists. Seven studies (5) looked at language skill development in language disadvantaged or disabled students. These studies were consistent in finding positive results related to computer use.

Finally, three studies looked at computer-augmented functional communication (6) and found positive results for communal writing and writing with telecommunications, particularly with disturbed adolescents.

Mathematics (not associated with programming)

Eleven studies examined CAI in mathematics drill, all with younger students (7). Most show a positive impact on both achievement and attitude, but the more recent studies offer a more critical insight. For example, the last three studies listed in (7) are excellent close examinations of CAI in terms of its differential effectiveness for high and low ability children and in comparison with paper and pencil drills.

Science

With two exceptions (8), science related studies generally related to simulations (9) or to Microcomputer Based Labs (10). The 13 simulation studies are encouraging. Students can learn well with simulations, but—and this point comes out consistently—they need guidance. The teachers' strategies for instructional integration of the simulation is a key factor.

The five studies on MBLs are also very encouraging, even suggesting that this is perhaps a major growth area for computer applications in instruction. Results are particularly good in relation to students' development of graph interpretation skills.

Other Learning Focuses

Databases

The six database studies (11) feature a variety of perspectives but all attest to the difficulties learners may have asking "good" questions of a database. The studies show that search strategies are related to various personal characteristics; that on-line "coaching" offers good potential; that, with guidance, learning disabled students can make good use of electronic searching; and that database use integrated with classroom instruction can transfer to strengthened "process skills" relating to the evaluation of information.

Preschool

Six studies focus on preschoolers and computer use (12). The results are all gently positive, particularly with regard to social interaction. The children in these studies are comfortable with computer use and generally display the same social behaviors around the computer as they do around other activities.

Logo

Two trends are clear in the 12 Logo studies (13). The teacher and the level of instructional support given to students using Logo are critical variables in influencing progress, and skills acquired in the context of using Logo are not likely to transfer to either particular mathematics insights or cognitive gains without instructional direction. These findings are also supported in a research summary article (88-89/12-1/2). Another finding that appears in a number of studies is that young learners have difficulty with the angle-related concepts in Logo, even with good supportive teaching. Another trend is clear: Logo research itself is getting better, from a design perspective. The many limits to generalizability that frequently appeared in earlier Logo "testimonials" are now better controlled, and the results show Logo to be a good tool, but not one which most students will use to much advantage on their own.

Programming and Computer Science

These are also topics where we have some disappointing trends (relative to early prediction about the potential of programming to improve higher level thinking). Most of the eight studies relating to (non-Logo) programming (14) fail to find any significant impact of programming experiences on anything else. Six studies looked at programming and computer science instruction more closely (15) and found that students need strong instructional guidance, particularly with respect to developing habits of thorough planning before hands-on coding. Flow charting is seen as having a negative impact on subsequent achievement.

Software

Design Features

The general conclusion I draw from the 20 studies dealing with "design features" (16) is that any feature will be more helpful to some learners than to others. By design features I mean options in the program, such as animation, screen display decisions, feedback strategies, display time, pacing, input alternatives, learner control, help options, responses to incorrect answers, uses of color, and so forth. Hativa's paper (87/8-9/4) is especially good in that it shows clearly how various design decisions can work to one student's disadvantage at the same time that another student can do well with them. The key conclusion here, I think, is to offer flexibility in options within software to accommodate individual differences in learners.

Evaluation

Only five studies dealt specifically with software evaluation (17). In general, they confirm that software evaluation has a large degree of subjectivity to it and that procedures to help teachers better evaluate software need to be found.

Teacher-Focused Studies

Surveys

Seven of our studies looked at surveys of teachers' uses of computers (18). They generally conclude with the same observation: teachers support the value of computer use in instruction, but are not yet making much use of it themselves. Often lack of appropriate teacher training is given as a major reason.

Teacher Training

There is general agreement in the five teacher training studies (19) that effective inservice should relate inservice experiences to classroom instruction, and should also involve some hands-on activities. The studies we reviewed include some innovative techniques for inservice but acknowledge that teacher training remains a difficult problem.

Support of Implementation

Perhaps the major trend I see emerging in the research over the last four years is the growing recognition of the impact of a complex set of "implementation variables" on any subsequent impact of computer experiences on students. Many of the studies acknowledge this, but four focus specifically on these implementation variables (20). Three additional studies offer some effective strategies to anticipate implementation problems (also 20). Fullan's paper (87/1/4) is an excellent study in this respect. He and his colleagues synthesize a large number of studies and conclude that we have "vastly underestimated how difficult it is for teachers to implement the changes new technologies will require in practice."

Other Topics

The seven studies relating to gender (21) generally conclude that, after a certain age, more males than females make use of computers, and that females tend to prefer cooperative rather than competitive computer activities. Four of the studies were interesting summaries of research (22). Two studies related to cost-effectiveness (23), a topic I predict will come into more and more focus, as I think it is inevitable that we will have to more systematically justify the time and money that we spend on computer activities in school. The attention given to cost-effectiveness in the OTA (Office of Technology Assessment) report—not reviewed in "Research Windows"—is I think an indication that more reliable indices of the impact of computer use in education are going to be called for. The remaining 11 studies (24) cover as many topics; space does not allow me to summarize them here. Let me say, however, that I found Mably's work on the potential of interactive video (89/2/3) to be especially interesting, as I predict this is also going to become a growth area in the future.

In the first issue of this year (88/8-9/1), I made three generalizations about trends and progress in research relating to the application of computers in education. After rereading my 180 reviews of studies for "Research Windows" for the last four years, I still endorse the same three generalizations:

- There are no easy answers or simple conclusions about the impact of computer use in education.
- Teachers are critically important in whatever happens when computers are used in education.
- Classroom implementation of computers is a complex and often challenging task.

To this list, however, I would add another generalization: computers have and continue to be remarkable catalysts for educational excitement and growth.

I have benefitted a great deal from the discipline of writing "Research Windows" each month. The time has now come to retire from the column, but not from my commitment to help build bridges between theory and practice. It is exciting to watch these bridges going up all over the world.

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Telecommunications: Make the connection.

Whether you want to hook up with a teacher in Kenya, or a teacher across town, ISTE's *Telecommunications in the Classroom* will help you make the connection.

Authors Chris Clark, Barbara Kurshan, Sharon Yoder, and teachers around the world have done your homework in *Telecommunications in the Classroom*. The book details what telecommunications is, how to apply it in your classroom, what hardware and software you'll need, and what services are available. *Telecommunications in the Classroom* also includes a glossary of telecommunications terms and exemplary lesson plans from K-12 teachers.

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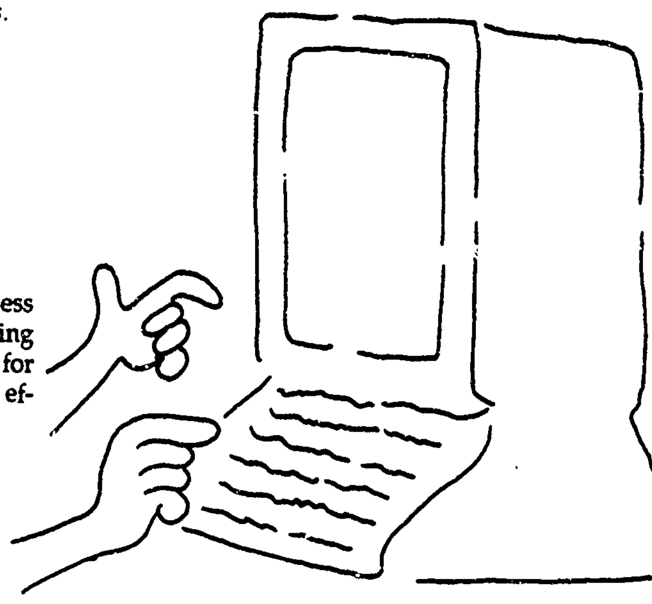
They have creativity in their little fingers.

Probably more than you realize. To help you capture some of that creativity, Randy Boone has compiled *Teaching Process Writing with Computers*.

This collection includes:
- research and position papers
- lesson ideas
- keyboarding
- reviews
- articles from *The Computing Teacher* and *The Writing Notebook*.

Randy Boone highlights ideas for teaching process writing with computers in the introduction, making *Teaching Process Writing Computers* an ideal tool for university courses, inservice workshops, or as an effective resource for classroom teachers.



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