The effects of computer-based instruction on college students' comprehension of classic research

JOSIE A. WELSH and CYNTHIA H. NULL
The College of William and Mary, Richmond, Virginia

Our purpose in this research was to determine the extent to which computer-based instruction can replace conventional teaching in experimental psychology. In Experiment 1, students from an advanced cognition and thinking course participated in a simulation of Schallert's (1976) study of the role of context in prose comprehension and in a simulation of Carpenter and Just's (1975) study of sentence-picture verification latencies. Half of the students completed each experiment with the computer, and half were taught traditionally. Comprehension of the purpose and design of the experiments was tested immediately after the laboratory session and 1 month later during the final examination. There were no significant differences between the groups. Several students in Experiment 1 appeared to rush through the experiments and pay little attention to the explanations. In Experiment 2, we studied the effectiveness of computer-based instruction in experimental laboratory sections that did or did not require a follow-up assignment. The second variable was introduced so that some factor of seriousness or importance of the laboratory exercise could be measured. Results from this study indicated that, regardless of the perceived importance of a laboratory exercise, students who studied classic research in a traditional setting comprehended the purpose and design of the experiment better than did the students who worked on the computer. In addition, the students assigned to write up the experiment performed better than did the students who were given no follow-up assignment.

When the computer was introduced to the educational system during the late 1960s, psychologists immediately began to evaluate it as a pedagogical tool. Considering the cost of implementing computer systems and of training teachers to use the new technology with confidence, educators demanded scientific proof of the effectiveness of *computer-assisted instruction*. Reviewers of these evaluation studies concluded that, at least in elementary school programs, *computer-based instruction* could enhance conventional methods of teaching (C. C. Kulik, J. A. Kulik, & Cohen, 1980b). (Whereas computer-assisted and computer-enriched instruction refer to a lesson taught by an instructor with the help of a computer program, computer-based instruction refers to a lesson taught by a computer program with no aid provided or discussion initiated by an instructor.)

Some skepticism still exists, however, with regard to the educational advantage of computer-based instruction in colleges and universities. In a 1974 review of studies of computer-based instruction in the college setting, Jamison, Suppes, and Welles settled on the conservative conclusion that such instruction is only about as successful as traditional methods of teaching are, when it is used to replace them. In the same manner, C. C. Kulik, J. A.

Kulik, and Cohen (1980a) concluded that the accomplishments of computer-based instruction must still be considered modest. Comparing the traditional way of teaching about release from proactive inhibition with a computerized experiment in which this phenomenon was demonstrated, Belmore (1983) found that the experimental and control groups showed approximately equal gains in knowledge. Similarly, after implementing a computer module called "Shapes," Spivey and Jackson-Smith (1983) concluded that computerization of traditional laboratory modules is not always for the best. Spivey (1983) insists that "no one would argue that all laboratory modules are best done on a computer, but rather, that some certainly are" (p. 186). Clark (1983) recommends that researchers refrain from future media comparison research. Focusing on radio (1950), television (1960), and computer (1970) research, he argues that:

all existing surveys of this research indicate that confounding has contributed to the studies attributing learning benefits to one medium over another and that the great majority of these comparison studies clearly indicate no significant differences. (p. 450)

A more recent metaanalysis suggests that there are significant gains in using one medium over another. In a study published in 1987, J. A. Kulik and C. C. Kulik conclude that students generally learn more in class when they receive help from computers. They report that, on the average, examination scores rose from the 50th to the 61st

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Requests for reprints should be sent to Josie A. Welsh, who is now at the Medical College of Virginia, Virginia Commonwealth University, Box 102, Richmond, VA 23298-0102.

percentile. In addition, Kulik and Kulik report that although computer-enriched instruction effects were near zero at the precollege level, computer-enriched instruction produced effects that were moderate in size in the college setting.

These findings demonstrate the need for continuing evaluation of computer-based instruction in colleges. Professors must be careful not to succumb to what Eamon (1986) calls illusions concerning computers: Educators have come to believe that teachers everywhere are successfully implementing revolutionary computer programs that consistently outdo traditional approaches to education. Such assertions have simply not been supported by psychological research, although the advent of microcomputers has meant that continuing research is necessary. As Hartig (1985) concludes,

since software is considerably more expensive than traditional media, teachers should not be satisfied simply with effectiveness. If it cannot be shown that CAI [computer-assisted instruction] is a *more* effective means of learning, the technology has not been fully tapped, and money has been wasted. (p. 5)

The evaluation of any teaching method is difficult, because it is often difficult to establish controlled conditions. Clark (1983) notes the importance of separating method from medium when one attempts to explain learning variance. All instructions, subject matter, content, and discussion must be identical when one is testing for differences between computer-based and conventional instruction. Only the media that are being compared can be allowed to differ. The proliferation of software available to professors complicates any general study of the benefits of computerization. For example, the usefulness of computer implementation could be contingent upon the instructor's choice of computer-based or computer-assisted teaching. Whereas in introductory courses the computer is typically introduced for tutorials or demonstrations, advanced laboratory courses include courseware such as experiment generators, data generators, experiment simulators, and "experimental sessions." Each of these types of software could provide different benefits to different college uses.

Although the hope of finding an effective tool for teaching lies at the core of computer research, any assessment of the effectiveness of computerization is limited by the vast range of definitions of effectiveness. For example, Belmore (1983) assessed software in terms of its superiority in helping students to gain knowledge in a particular area as well as its capacity to enhance a student's enjoyment and interest in a particular course. Hartig (1985) considered effectiveness in terms of how well the student liked computers after using software for coursework. Thus, anyone studying the use of computers in education must define effectiveness clearly.

Although there are inherent problems in computer research, the fact that colleges and universities are implementing computer-assisted instruction under the assumption that it improves learning is a reason to assess this costly endeavor. Castellan (1986) warns faculty

against introducing computers in a piecemeal or haphazard fashion. As he explains,

In reading the promotional literature provided by publishers, one has the *impression* that it is easy to introduce computer-based instructional materials into one's class. Time and again, our experience shows that integration of computers into coursework is strewn with traps and pitfalls for the unwary. (p. 252)

The question of how to get the most out of computer-assisted instruction at the college level still remains largely unanswered in the literature. By considering the aforementioned pitfalls and conducting controlled experiments, researchers should be able to assess more accurately the extent to which a college class or laboratory session can, or should, be computerized. The following experiments were conducted to examine the effects of computer-based instruction in an advanced laboratory setting. It was hypothesized that students who participated in an experimental session using computer software would be free from concerns with equipment and data collection and would comprehend more of the methodology and design of a classic experiment than would students who performed the experiment in a traditional classroom setting.

EXPERIMENT 1

Method

Subjects. The subjects were 24 college students (7 males, 17 females) enrolled in an advanced laboratory in cognition and thinking. The subjects were assigned randomly to either the experimental condition, which involved computer-based instruction, or the control condition, which consisted of conventional teaching.

Materials. The software chosen for this study was Keenan and Keller's (1988) *Computer Lab in Memory and Cognition*. The specific programs used were the experimental session of a modified replication of Schallert's (1976) work on the role of context in prose comprehension, and the experimental session of Carpenter and Just's (1975) sentence-picture verification. These programs allow students to participate as subjects, view a data summary, and read about the theoretical background of these well-known studies. Keenan and Keller's (1988) program meets criteria that Johnson (1986) lists as important for the evaluation of courseware. Specifically, the *Lab in Memory and Cognition* allows for participation and experimentation, incorporates sound learning principles, and provides the user with a discussion of results at the close of the experimental session. In addition, the software is user-friendly, and it is consistent with curricular goals.

Materials for the Schallert (1976) experiment in the control condition consisted of typed stories and questions identical to the items read by students using the computer. The subjects in the conventional condition were also given data sheets to record responses.

The apparatus for the Carpenter and Just (1975) experiment in the control condition consisted of a tachistoscope wired to a Hunter Klocktimer and a control box. The control box contained green and red buttons, which could be

depressed to start and stop the "klocktimer." Stimuli for the sentence-picture verification task were drawn on 4 × 6 index cards with a black felt-tip pen.

Procedure. All of the subjects were told that they were about to participate in an experiment that would include short-answer questions concerning the material presented. They were asked to sign a consent form, and they were told that they could refuse to answer any question and/or discontinue participation at any time. After the subjects were assigned randomly to conditions, Instructor 1 took the experimental group to the computer lab, where the program had already been loaded into personal computers. The students in that condition were given a hand-out explaining how to run the program and print the data that is presented at the end of the session. As each subject completed the computer program, Instructor 1 handed the student an assignment to be completed immediately and turned in to the instructor. The assignment included questions concerning the design and methodology of the experiment, as well as the theoretical interpretation of results. As the students turned in their responses, Instructor 1 thanked them for participating and informed the students that, at the end of the next semester, the results would be posted on the first floor bulletin board of the psychology building.

The students in the control condition remained in their classroom, where Instructor 2 read verbatim instructions included in the *Computer Lab in Memory and Cognition*. The students were then instructed to conduct two experimental sessions, serving once as the experimenter recording the data and once as the subject answering questions. After the students in the control condition read typed stories from Schallert's (1976) study, Instructor 2 explained the role of context in comprehension of stories as it was explained by the computer to the students in the experimental condition. Next, Instructor 2 handed out the assignment described in the computer condition and collected the completed work. Instructor 2 informed the students that the results of the study would be posted on the bulletin board on the first floor of the psychology building at the end of the next semester.

Two weeks later, another experiment was conducted with the same subjects and instructors. This experiment differed from the previous one in that the Carpenter and Just (1975) sentence-picture verification task constituted the experimental session. The subjects switched conditions, so that each student had an opportunity at some time to work on the computer. Instructor 1 remained in the experimental condition, while Instructor 2 stayed in the control group. The procedure for this experiment was identical to that described above.

At the end of the semester, questions concerning the two experiments appeared on the students' final examination. The instructor indicated that answers to these questions would not be considered in determining final grades. As part of a standard course evaluation, the students were asked to provide feedback concerning their participation in the current study.

Results

It was hypothesized that the computer group would do better in both the Schallert (1976) and the Carpenter and Just (1975) experiments. Because the Carpenter and Just experiment involves more data collection and more elaborate equipment that must be mastered, it was expected that differences between the two groups would be greatest for that study. Mean scores for knowledge were not significantly different for the groups (see Table 1). The conventionally taught group scored higher for both the Schallert (1976) and the Carpenter and Just (1975) experiments ($M = 52.8$ and 45.8 , respectively), while the computer group scored 51.9 and 38.6 . Neither of these differences was significant [$t(19) = .19$, $p > .05$, for Schallert; $t(19) = .89$, $p > .05$, for Carpenter & Just]. Results from the final examination also indicated no significant differences between the groups. Means for the Schallert (1976) experiment were 26.6 ($SD = 43.9$) for the conventionally taught group and 24.2 ($SD = 36.7$) for the computer group [$t(19) = .89$, $p > .05$]. Means for the Carpenter and Just (1975) study were 39.3 ($SD = 21.4$) for the traditional group and 27.2 ($SD = 26.1$) for the computer group.

EXPERIMENT 2

During Experiment 1, Instructor 1 noted that although the students were completing the experiments, many of them were not taking time to read the computer explanation of the purpose of the experiment and the results. It was further noted that none of the groups performed well on the dependent measure of overall comprehension of the experiment. It appeared that students in both conditions were eager to complete the laboratory assignment and finish early. There was no grade given for these particular laboratory exercises, nor was any outside assignment required. These factors, taken together, led the instructor to question whether or not some factor of seriousness had influenced the results of the two experiments. This variable was tested in Experiment 2.

Method

Subjects. The subjects were 75 students (17 males, 58 females) enrolled in experimental psychology. Thirty-eight students were enrolled in a laboratory section in which an APA-style report of the Carpenter and Just (1975) study was required. Thirty-seven students were enrolled in a laboratory section in which no assignment was given for this particular exercise.

Table 1
Percentage of Questions Answered Correctly
as a Function of Instructional Method

Instruction	Experiment	<i>M</i>	<i>SD</i>
Conventional	Carpenter and Just (1975)	45.8	12.0
	Schallert (1976)	52.8	11.3
Computer	Carpenter and Just (1975)	38.6	22.7
	Schallert (1976)	51.9	10.6

Apparatus. The Carpenter and Just (1975) experiment was used exactly in the same manner as it was in Experiment 1. The Schallert (1976) study was not used, because the design did not involve any equipment or apparatus that clearly distinguished the computer group from the conventional. The dependent measure was again the percentage of questions about the experiment answered correctly. Some of the detailed questions concerning the explanation of Carpenter and Just (1975) were eliminated, because no one in the first study had answered them correctly.

Procedure. The procedure for Experiment 2 was identical to that in Experiment 1, except that manipulation checks were added. After having answered questions concerning their overall comprehension of the purpose and design of the Carpenter and Just (1975) study, the students were asked to what extent they took the exercise seriously, to what extent they paid attention to the explanation of the study, and to what extent they felt that their understanding of the laboratory exercise would affect their final grade in the course. When the study was completed, all students who were required to write an APA-style report of the experiment were given a handout explaining the theoretical background of the Carpenter and Just study, and the manual for the computerized experiment was available from the college library.

Results

An ANOVA of the subjects' course grades through mid-semester revealed no significant differences. Thus, intact groups did not present a problem in this study. A 2×2 (importance $\times$ instruction) ANOVA revealed significant main effects for both factors (see Table 2). The students in the conventional condition performed better [$F(1,71) = 7.2, p < .01$], and the students who were given an assignment for the lab performed better [$F(1,71) = 4.2, p < .05$].

The required APA-style, follow-up assignment worked to create a factor of seriousness or importance. The students who were given a laboratory assignment took the exercise more seriously [$F(1,71) = 7.3, p < .001$] and felt that their grades would be affected by their performance [$F(1,71) = 26.1, p < .001$]. In addition, the students in the computer condition paid less attention to the explanation of the purpose of the Carpenter and Just (1975) study and to the explanation of their findings [$F(1,71) = 16.8, p < .001$]. Means for attention paid by subjects in the classroom were 6.6 (on a 9-point scale)

Table 2
Mean Performance as a Function of Method of Instruction and Perceived Importance of Laboratory Experiment

Instruction	<i>M</i> (% correct)	<i>SD</i>	<i>n</i>
Conventional/assignment	72.2	19.2	18
Computer/assignment	60.3	13.8	20
Conventional/no assignment	62.9	20.1	18
Computer/no assignment	52.7	17.7	19

Table 3
Required Time to Complete Task as a Function of Method of Instruction and Perceived Importance of Laboratory Experiment

Instruction	<i>M</i> (in min)	<i>SD</i>	<i>n</i>
Conventional/assignment	72.2	5.8	18
Computer/assignment	44.0	7.0	20
Conventional/no assignment	75.7	10.0	18
Computer/no assignment	48.6	4.7	19

for the group that was given an assignment and 5.6 for the no-assignment group. Means for the subjects working on the computer were 5.4 for the group given an assignment and 3.0 for the no-assignment group.

Finally, there was a significant difference in the amount of time students spent working on the laboratory experiment. People in the computer condition spent significantly less time on the assignment [$F(1,71) = 5.7, p < .05$]. (See Table 3.)

GENERAL DISCUSSION

The purpose of these studies was to determine the ability of computer-based instruction to surpass that of conventional teaching of classic experiments in psychology. Contrary to the hypothesis, the students in the conventionally taught group performed better than those using a computer. In addition, students who were required to write an APA-style report of the laboratory experiment exhibited better understanding of the classic research. These findings are specific to the experiment simulator used in the current study. Results from experiment generators or data generators, or results from other software packages, could provide more evidence concerning the use of computers in psychology.

In this study, experience with computers was not tested, because all students had been taught a statistical package as part of their coursework. Effects of novelty were not considered, because research by J. A. Kulik, Bangert, and Williams (1983) and by C. C. Kulik, J. A. Kulik, and Cohen (1980a) has shown that although such effects have confounded findings at the secondary school level, this problem is not evident in studies involving college students.

Two instructors were used in this study, so that the two groups of students could work on the laboratory experiment concurrently. According to J. A. Kulik and C. C. Kulik (1987), it is unclear whether experiments with one instructor or two yield the most accurate assessment of computer-based instruction. Effects of computer-based instruction have been shown to be stronger in experiments in which different instructors teach the control and experimental groups. The reason for this finding is not clear (J. A. Kulik & C. C. Kulik, 1987).

Although the conventional group that was given an APA-style assignment performed the best, and the computer group with no assignment did the worst, this interaction was not significant [$F(1,71) = .04, p > .05$].

The finding that students perform better if they perceive the laboratory exercise to be an important part of their course grade is supported by the research of Ksobiech (1976). Ksobiech found that students achieved increasing scores when they were told they were expected to enjoy, evaluate, or take a test on the subject of presentation. Students performed best when they perceived that they would be graded on the presented material.

The finding that people who used computers took less time to complete the laboratory experiment is consistent with a series of research findings that have highlighted the more efficient use of time with computer instruction as opposed to human instructors. For example, Belmore (1983) found that when conventional teaching required 1 h, the computerized laboratory took 25 min. Results from the current study showed, however, that the group that finished first performed the worst. What has been labeled computer efficiency could be a product of an unattentive student eager to complete the experiment. A learning environment that could reduce time spent in the class without sacrificing quality of instruction would be an ideal worth pursuing.

It appears, then, that conventional teaching is more effective than computer-managed instruction at the college level (at least for the software used in this study). Another way of stating this is to say that a human instructor is an essential factor in teaching college students. Because the current study showed that performance in conventionally taught laboratory research exceeds performance with computer-based instruction, the only question to be answered is whether or not performance in conventionally taught laboratory research also surpasses performance with computer-assisted instruction. Computer-assisted instruction could be incorporated into the laboratory classroom through the use of the computer to present stimuli and record data, followed by a concluding discussion led by a human instructor. Indeed, this is the format suggested by Keenan and Keller (1988) in their software manual. Results from such a study would provide experimental evidence that would enable instructors to make informed decisions about the implementation of computer instruction at the college level.

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