Technologically Assisted Instruction and Student Mastery, Motivation, and Matriculation

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Computer-based teaching methods can improve the transfer of information, increase instructional focus on conceptual and methodological skills, enhance motivation, and stimulate the development of expressive skills. After reviewing a number of studies of computer-based applications, we report a correlational study of psychology students' attitudes and achievement in a technologically enhanced classroom. The results indicated that (a) students rated the computer-based instructional components positively, (b) those with weak academic backgrounds who consistently used the technology achieved higher test scores than weak students who did not use the technology, and (c) students who dropped out of college the following semester tended to be low users of technology. We also discuss the implications of computer technology for teaching.

Advances in computers and information processing are changing the way students study and the way professors teach psychology. Instructors once taught by assigning readings and papers, lecturing, and leading discussions. Now, they can use computer-based technologies to supplement these traditional methods of teaching. In this article, we briefly review some of these applications of computers to teaching. We then present findings that speak to the relation between students' use of technology and learning, motivation, and continued enrollment in the university.

Computerized teaching technologies spring from Skinner's early vision of a teaching machine that would shape students' behavior through reinforcement (Benjamin, 1988). Currently, computer technology offers alternative means of disseminating information, motivating learners, and stimulating independent learning. For example, e-mail and the World Wide Web offer instructors an alternative way to communicate course content efficiently and accurately. Other computer applications, such as hypertext and multimedia programs, combine visual, auditory, and graphical data in an integrated format. If these programs are interactive, they provide the learner with feedback and additional instruction when needed. Many applications also increase students' control over the learning process. Students who need additional help can carry out exhaustive reviews of their text, multiple drills, and self-quizzes using computer-based study guides. Advanced students can obtain supplemental material from electronic archives. Those who are unsure if they are learning the material can seek feedback by taking practice quizzes.

Do these high-tech teaching tools enhance learning and motivation? Prior studies of the relation between using computer-based teaching technologies and student outcomes (e.g., learning, motivation, and matriculation) offer modest support for these new methods (Chaparro & Halcomb, 1990; C. L. C. Kulik & Kulik, 1991; J. A. Kulik, Bangert, & Williams, 1983; J. A. Kulik & Kulik, 1987; Niemiec & Walberg, 1987). For example, Worthington, Welsh, Archer, Mindes, and Forsyth (1996) used a quasi-experimental design to compare the relative advantages of adding a 1-hr session in a technologically enhanced classroom (TEC) to the traditional 3 hr of lecture per week in an introductory psychology course. They found that exposure to the TEC resulted in higher performance on the final examination, adjusted for grade point average (GPA) and attendance. This performance gain was even greater on items that tested students' understanding of concepts taught in both the lecture and TEC.

Researchers have obtained similar positive results when examining the value of adding computer-based learning components to such courses as experimental psychology (Chute, 1986; Goolkasian, 1989; Monahan, 1993; Perone, 1991), introductory statistics (Marcoulides, 1990), and educational psychology (Grabe, Petros, & Sawler, 1989). For example, Duncan (1991) found that computer-based instruction improved students' test scores in an experimental design course. Petty and Rosen's (1990) students had higher test scores in an experimental design course when they used computer tutorials and simulations, and students also reported increased enjoyment with the course. Marcoulides (1990) found that students in an introductory statistics course performed significantly better on a statistics achievement test when using computer-based teaching aids as compared to those in a lecture group without such software.

The evidence is not uniformly positive, however. For example, Welsh and Null (1991) reported that traditional teaching methods in research design were more effective than computer-based methods. Sawyer (1988) found that computer-based tutorials did not improve performance over traditional workbooks. These studies suggest that computer-based instructional components may not increase learning if these components are used in place of traditional teaching methods. These contrary findings could also be due to the type of instructional technology used and students' reaction to the technology. For example, a text-based tutorial may not be as effective as a graphics-rich interactive simulation, and students may not benefit from technology if they rarely use it or find it dull.

This investigation extends these prior studies of the relations between students' use of several types of instructional technology and their learning rate, motivational levels, and retention in college. The participants were students in an introductory psychology course who also attended, as a class requirement, a 1-hr learning session in a TEC. We conducted the study to answer three questions about the course. First, how did students evaluate the intervention? Did they consider the TEC sessions to be motivating and helpful, or irrelevant and time consuming? Second, was use of computer technology related to achievement? Did students who made use of the technology have higher grades than those who did not? Third, was the intervention related to matriculation? Did students who used technology while studying psychology persist in their studies by enrolling the next semester or did they withdraw from college?

Method

Participants

All participants were enrolled in a single section of Introduction to Psychology. The class met for 3 hr per week in a large lecture hall and 1 hr per week in a 25-seat TEC. The sample included 144 women and 63 men (49 African Americans, 138 Whites, and 24 Asians). Several individuals did not complete all measures, including 4 who did not report their sex.

Procedure

The instructor urged students to attend the lectures, but noted that attendance was not mandatory. On most days, about 60% of the students attended. The instructor presented traditional lectures on various psychological topics and administered all the major course examinations.

The TEC sessions were held in one of two 25-station rooms equipped with MS–DOS®-based computers networked to a server and printer. The available software included a group of basic tools (e.g., writing and filing programs), network tools (e.g., e-mail and access to the university library catalog), and a group of psychology-related tools (e.g., multimedia simulations, hypertext, and lecture notes). Students could also access two computer-based news groups where class members could post messages and comments and browse the World Wide Web. At the start of each TEC session the instructor described the programs that students would run, reminded students to read their e-mail, identified optional programs that were available for students if they wanted additional information, and took attendance.

Students could use their time in the TEC to run any program they chose after they had completed the required exercises. The exercises we required usually included simulations of psychological processes, demonstrations of classic experiments, and hypertext tutorials. Simulations taught concepts such as hemispheric specialization, visual illusions, and statistical correlations. Several exercises created virtual laboratories (Ludwig, 1996) by replicating studies such as Sperling's (1960) iconic memory study and Deutsch and Krauss's (1960) trucking game. The hypertext tutorials provided additional information on a variety of subjects. Students answered an online multiple-choice quiz or completed an essay assignment through e-mail each week in TEC.

In addition to classroom time, students could use the TEC facilities for up to 4 hr during open TEC sessions to seek additional help or complete unfinished work. TEC instructors who staffed the classroom during these open hours recorded student attendance and reported this information to each students' TEC instructor. Students could also access some TEC resources (e-mail, online lecture notes, and news groups) from other university locations or through dial-in modems.

Measures

Class and university records. Class records included grades on course examinations, quiz grades, and attendance. University records provided students' majors and their enrollment status the following semester.

TEC instructor ratings. The instructors in the TEC sections, at the end of the semester, rated each student's use of technology as *heavy, frequently, occasional, infrequent,* or *never used.* They also indicated whether the student used the class computer-based bulletin board or the e-mail system beyond that required for class papers. Instructors also judged whether the student, in their opinion, displayed a positive attitude about TEC.

Student survey. Two weeks prior to the semester's end students completed a questionnaire in their TEC session. In addition to demographic items and items pertaining to experience with computers, the survey included 14 items asking about students' general evaluation of the experience. Students indicated their agreement or disagreement with the items using a Likert 5-point scale ranging from 1 (*disagree strongly*) to 5 (*agree strongly*). The students also evaluated each component of their TEC using a 5-point scale ranging from 1 (*very unfavorable*) to 5 (*very favorable*), and they estimated the time they spent using each component on a 5-point scale ranging from 1 (*never*) to 5 (*a great deal*).

Student ratings of instruction survey. Students, by university mandate, complete an anonymous evaluation of all their classes each semester. We added five items dealing specifically with TEC to this survey's standard items. Students completed this anonymous survey in their lecture section using the 5-point agree–disagree scale described previously.

Results

General Experience and Attitudes

Fewer than 5% of the students reported having no computer experience, 23.1% reported having a little experience, 38% reported having some experience, 20.8% reported using computers regularly, and 13.4% reported having a great deal of experience. Fewer than 2% reported they were fearful about using a computer. However, 25.8% reported feeling uncomfortable when using a computer.

Student Evaluations of Technology

General evaluation. Table 1 presents means and standard deviations for the items used to assess students' opinions of their TEC experience. These data suggest that students, in general, had positive opinions of the intervention. The students generally agreed that TEC was a positive learning experience and helpful. They did not feel that TEC was a waste of time. The low mean for the item "I might have dropped the course were it not for TEC" was due, in part, to the responses of psychology majors in the class who required the course. Their mean ($M = 1.7$, $SD = 0.92$) was lower than the mean ($M = 2.2$, $SD = 1.04$) found for the other majors, $F(1, 211) = 9.29, p < .01, R^2 = .042$.

Ratings of specific components. As the means shown in Table 2 indicate, students were mostly positive in their evaluations of the various aspects of the intervention. They most preferred the informational resources, such as online lecture notes and study information. They were less positive toward the more evaluative aspects of TEC, such as quizzes and e-mailed homework assignments. Students evaluated the general discussion news group least positively.

The means for time spent using each component, presented in Table 2, suggest that individuals spent the most time using components that they evaluated most positively. Quizzes (which were mandatory) and e-mail to the instructor (which few students used with great frequency) were exceptions to the general tendency. We created two indexes, one pertaining to overall evaluation and one pertaining to usage rate, by averaging the evaluation items and the usage estimates. These indexes had adequate internal consistency, as indicated by Cronbach alphas of .79 and .80, respectively. The means for these indexes ($M = 3.90$, $SD = 0.61$; $M = 3.39$, $SD = 0.63$, respectively), indicate a generally positive appraisal and usage rate. They were also intercorrelated, $r(213) = .69, p < .001$.

A two-way interaction of gender and ethnicity, detected in a least-squares analysis of variance (ANOVA) that took into account the nonorthogonality of the factorial design, emerged as significant only for usage rates, $F(2, 198) = 3.24$, $p < .05$, $R^2 = .031$. Asian American men reported higher usage rates than African American men ($p < .05$), with White men falling intermediate and not differing from these two groups, respectively ($M = 3.80$, $SD = 0.40$; $M = 3.03$, $SD = 0.70$; $M = 3.36$, $SD = 0.69$). No differences emerged for women ($M = 3.44$, $SD = 0.68$; $M = 3.55$, $SD = 0.56$; $M = 3.34$, $SD = 0.65$, respectively). Also, although age was not correlated with these two variables, high-school GPA and average time spent using the components were correlated, $r(199) = .16, p < .05$.

Student ratings of instruction. Students responded to the following five items dealing specifically with the TEC on the Student Ratings of Instruction survey they completed in their lecture section:

1. The TEC sessions are well-organized.
2. The content of the TEC is a worthwhile part of this course.
3. TEC assignments are reasonable in length and complexity.

Table 1. Means and Standard Deviations for Items Used to Measure Opinion of TEC

Item	*M*	*SD*
TEC was a positive learning experience	3.87	0.90
I considered TEC to be helpful	3.87	0.95
TEC gave me a way to improve my grade	3.78	0.95
TEC gave me ways to improve my grade in the class	3.78	0.89
I gained valuable information from TEC	3.76	0.95
TEC improved my learning	3.69	0.93
TEC had a positive impact on me	3.64	0.94
TEC improved communication between me and my instructor	3.18	1.07
TEC motivated me to work harder at my studies	3.13	0.94
TEC increased my confidence in myself as a student	3.08	0.90
The TEC work inspired me to work harder	3.04	0.89
I did not make much use of the TEC materials	2.27	1.13
TEC was a waste of my time	2.22	1.06
I might have dropped the course were it not for TEC	2.13	1.04

Note. Means range from 1 (*disagree strongly*) to 5 (*agree strongly*). TEC = technologically enhanced classroom.

Table 2. Mean Rating of, and Estimate of Time Spent Using, Each Aspect of TEC

	Rating		Time	
Item	*M*	*SD*	*M*	*SD*
Online lecture notes	4.28	0.85	3.60	1.28
E-mail feedback on performance	4.23	0.79	4.04	1.02
Online chapter outlines	4.13	0.85	3.67	1.15
Access to the Internet	3.97	0.92	3.47	1.36
Online information about studying, tests, and so forth	4.01	0.88	3.54	1.06
E-mail connection to the course instructor	3.93	0.85	2.59	1.52
The computerized study guide	3.81	0.88	3.03	1.24
E-mail homework assignments	3.83	1.14	4.12	0.96
Multimedia learning programs	3.75	0.89	3.45	0.89
Electronic quizzes	3.69	1.11	4.01	0.88
Online summaries of lecture	3.63	0.81	2.81	1.25
Class news group (bulletin board)	3.45	0.91	2.36	1.20

Note. Means range from 1 (*very unfavorable*) to 5 (*very favorable*) for rating and from 1 (*never*) to 5 (*a great deal*) for estimate of time spent using the component. TEC = technologically enhanced classroom.

4. TEC assignments have instructional value.
5. I had sufficient opportunity to use TEC facilities.

The means for these items (Ms = 4.1, 4.0, 4.1, 3.9, and 3.9, respectively) indicate that students were generally positive in their opinions of the TEC, even when they responded anonymously.

Student Use of Technology

What factors related to the students' use of technology? We examined this question by dividing students into two groups based on their attendance records. Those in the heavy-use group missed, at maximum, only 1 TEC. Students in the light-use group missed at least 2 TECs.

These students differed on several variables that indexed their use of technology. First, although they did not differ in their evaluation of TEC, they reported using the various components of TEC at different rates, $F(1, 213) = 4.32, p < .05, R^2 = .02$. The mean usage rate for heavy users was 3.46, whereas the mean for light users was 3.22 (*SDs* = 0.60 and 0.72, respectively).

Second, TEC instructors rated students in the two groups differently. Instructors identified 72 who were rare users of technology, and 81.9% of them were in the low-attendance group. In contrast, the TEC instructors rated 95 students as frequent or heavy users, and 81.1% of them were in the high-attendance group, $\chi^2(1, N = 280) = 72.95$, $p < .01$, $\Phi = .51$. Of the 154 students who used the computerized bulletin boards regularly, 74.7% were in the high-attendance group, $\chi^2(1, N = 234) = 45.99, p < .01, \Phi = .44$. Of the 132 students who used e-mail beyond that required during the TEC class session, 72.2% were in the high-attendance group, $\chi^2(1, N = 214) = 23.90, p < .01, \Phi = .32$. Of the 219 students who displayed a "positive attitude" about TEC during their session, 67.7% were in the high-attendance group, $\chi^2(1, N = 251) = 43.67, p < .01, \Phi = .42$ These ratings justify the labels *heavy users* and *light users*.

Technology Use and Learning

Was technology usage related to achievement? Comparison with grade distributions obtained in the test year (1994) and prior years (1992 and 1993) showed little evidence of academic gain. For example, 10.5% of the students received grades of A in prior years whereas only 8% received As in 1994. Twenty-seven percent of the students earned *D*s or *F*s in prior years compared to 29% in 1994.

Students did not evidence greater gains in performance when they used the TEC, but these data are inconclusive. We developed the components used in TEC over time, so students in earlier years also used computerized study guides and online lecture outlines. Moreover, the lack of improvement in 1994 could be due to a number of factors, such as changes in the text used, exams given, lectures presented, and quality of the students enrolled.

Because only some students diligently used the TEC sessions, we indirectly tested the usefulness of the technology by examining the achievement rates of light versus heavy users of technology. Table 3 presents the distribution of grades for the course for both heavy and light users of technology. The chi-square test was significant, $\chi^2(4, N = 285) = 46.71, p < .01, \Phi = .41$, and indicates that heavy users outperformed light users. Heavy users earned 85% of the As awarded and 75% of the *B*s. In contrast, light users earned 78.4% of the *F*s in the class.

Table 3. Grade Distribution of Heavy Technology Users and Light Technology Users

User	A	B	C	D	F	Total
Heavy	17	51	51	26	11	156
Light	3	17	40	24	45	129

Table 4. Exam Performance for Academically Strong and Weak Students by Level of Technology Use

	Heavy User			Light User		
	M	*SD*	*n*	*M*	*SD*	*n*
Strong[a]	76.25	10.87	84	74.53	11.89	89
Weak[b]	71.19	12.59	72	62.37	11.73	41

[a]Grade point average > 3.0. [b]Grade point average < 3.0.

These findings illustrate the relation between technology usage and the grades students actually earned in the class, but they may overestimate the strength of this relation because attendance in TEC defined the light-usage and heavy-usage classification and was included in grade calculations. Also, this analysis does not take into account students' academic background. To deal with these limitations, we also classified students into one of two groups based on self-reported high-school GPA. Academically weak students reported GPAs of less than 3.0 whereas academically strong students reported GPAs of 3.0 or more. We used a 2 (academic background) × 2 (TEC use) least-squares ANOVA to examine the average of students' scores on the three standardized tests administered in the lecture section of the class. All effects (academic background, TEC use, and their interaction) reached significance, $Fs(1, 282) = 31.33, 17.14$, and 5.97, $ps < .01$, $R^2s = .089, .049$, and $.017$, respectively. The means in Table 4 indicate that strong students had higher scores than weak students and that heavy users had higher scores than light users. Simple effects tests of the interaction, however, indicated that academically weak students who used TEC and students with stronger academic backgrounds outperformed students with weak academic backgrounds who did not use TEC heavily, $F(1, 282) = 58.30, p < .01, R^2 = .13$. Academically weaker students who were also light TEC users received grades in the low *D* range, whereas students who used TEC heavily received Cs.

Withdrawal and Enrollment

Because the TEC sessions required additional time and effort from students, the extra requirements could have increased the rate at which they withdrew from the course, particularly if their overall interest in the course was low. If, however, the resources provided to students in TEC (copies of lecture notes, chapter outlines, the means of communicating with one another and their instructor) increased their motivation and offered an alternative means of acquiring course information, then heavy users of TEC should be more likely to remain in the class until its conclusion.

Of the 34 students who withdrew from the course, either through formal procedures or simply by not taking the final exam, 33 were light users of technology and 1 was a heavy user. This finding should be interpreted cautiously, however, because usage was determined by attendance at TEC sessions (and a student who has withdrawn would not attend such sessions). However, registration at the university in the following semester did relate to technology usage, $\chi^2(1, N = 285) = 5.20, p < .05$, $\Phi = .135$. Of the 31 students from this class who did not register at the university in the following semester (about 10% of the class), 20 (64.5%) were low-technology users.

Discussion

Computer-based instruction has received mixed reviews, but the general conclusion seems positive: Computer-based instruction improves test performance and attitudes (Duncan, 1991; Goolkasian, 1989; Marcoulides, 1990; Worthington et al., 1996). This study affirms this general conclusion, to a degree. First, students enthusiastically endorsed their computer-based learning experiences. They agreed to such items as "TEC was a positive learning experience" and "I considered TEC to be helpful." Second, students who used the technology had higher grades than those who did not, but only if their academic preparation was weak. Stronger students (higher GPAs) who used technology achieved slightly higher scores on tests than those who did not use technology (76.3% vs. 74.5%). Weak students who were technology users averaged 71.1%, but weak students who did not use technology scored 62.4%. Third, use of technology related to matriculation at the university the following semester. Nearly two thirds of the students who dropped out were low-technology users.

The strength of the conclusions must be tempered by the nonexperimental nature of the design used in this investigation. All students had the opportunity to use the technology, thus they self-selected into the categories of light user and heavy user. Any factor that influenced that selection process (e.g., motivation, time pressures, or intelligence) could be the causes of the gains noted. The pattern of results obtained could also reflect the impact of achievement on computer use, for students who began performing poorly in the course may have stopped using the technology. The results pertaining to matriculation must also be interpreted cautiously because some students who withdrew from the university may have transferred to another college. The variety of technological resources, too, makes it difficult to determine which aspects of the intervention were the most pedagogically beneficial. Students e-mailed short essays, ran tutorials, participated in simulated experiments, completed online quizzes, read hypertext explanations of psychological concepts, and could access the World Wide Web. The elements in this list that most influenced their learning cannot be determined.

The findings, however, are encouraging, for they suggest that technology offers a way to improve the way faculty teach and students learn. In terms of information dissemination, computers provided an alternative way to communicate course content efficiently and accurately. Rather than relying only on lectures and printed text, students could acquire information from many other sources. The instructor copied his lectures and notes to the campus-based computer system, where students could review them during the semester. Students could also acquire information about psychology by searching the World Wide Web or databases of journal abstracts such as PsycLIT.

The computerized learning experiences were also more involving for students. In the lecture, the instructor decided what topics would be covered and in what depth. In contrast, students gained control over their learning experiences in TEC. When a particular topic interested them, they could delve deeply into the subject. If they felt challenged by a concept or topic, they could rerun programs and move through them slowly. Students who needed additional pedagogical support could carry out exhaustive reviews of their text, multiple drills, and self-quizzes using computer-based study guides. Students who were unsure if they were learning the material thoroughly could take practice quizzes.

The intervention also illustrates the importance of systematically pursuing feedback about the use of technology in teaching (Castellan, 1993; Duncan, 1993). We expected, for example, that students would most prefer using the more glamorous, multimedia programs. However, they actually preferred the online services such as e-mail and feedback from their instructors. The data also dispel certain myths pertaining to the use of computers in teaching. The intervention did not help only the best students. Consistent with other studies, the poor students who used the technology showed the greatest gains (Skinner, 1990). Moreover, we found no substantial differences due to sex or racial background. Students showed little distaste or fear of computers in the classroom. They were irritated by breakdowns, but they were generally positive about the use of the machines. Some, in fact, preferred to use technology rather than listen to the lecture.

More generally, the intervention suggests that technology is changing the way students learn and professors teach. Students, with the help of the faculty, created personalized educational experiences that matched their needs and goals. The course instructor often taught from a distance, sending answers and information to students electronically. Face-to-face meetings during office hours declined, but time spent responding to students' e-mail messages increased. Instead of creating lectures, faculty spent time creating written materials for students to read online and researched various instructional programs that students could use. The use of computerized classrooms restructured some fundamental aspects of the learning environment, and it remains for future researchers to explore the ramifications of these changes.

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Notes

1. Funds for the development of the technologically enhanced classrooms used in this project were provided, in part, by an Equipment Trust Fund grant from the State Council of Higher Education in Virginia (SCHEV). Development of the curriculum was made possible by SCHEV grants to the Central Virginia Faculty Consortium project "Teaching, Learning, and Technology: Preparing Faculty for the 21st Century" and the "Improving Student Satisfaction and Success in the Large Classroom Environment" project.
2. Thanks are extended to Jon Wergin, Jean Yerian, and the members of the Central Virginia Faculty Consortium for their contributions to the design of the computer-based classroom; Jim Spivey and Mike McDaniels for technical support; Ken Guyre for his assistance with newsgroups; Mark Stasson for statistical counsel; and the anonymous reviewers who suggested ways to strengthen the original article.
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