COMPUTERS IN TEACHING

Computer-Assisted Instruction as a Supplement to Lectures in an Introductory Psychology Class

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Educational benefits of computer-assisted instruction (CAI) were investigated. A quasi-experimental design contrasted learning outcomes of students in an introductory psychology class that incorporated CAI exercises to students in a lecture-only introductory psychology class. A number of potential mediating variables, such as instructor, size of class, textbook, and year in school, were controlled. Analysis of students' final examination scores indicated that students in the lecture-plus-CAI section obtained higher scores than students in the lecture-only section, and these higher scores were due to their better performance on concepts that were taught in both lecture and CAI exercises. These findings offer modest support for the use of CAI as a supplement to lecture in teaching psychology, particularly for domain-specific learning.

Introduction to Psychology serves as a general introduction to psychological research and theory. By tradition, much of the learning in the course comes from reading the textbook and attending lectures. Recent technological developments, however, offer instructors an additional method for teaching psychology's content and process. Computer-assisted instruction (CAI) continues to evolve, ultimately offering several advantages. Interactive CAI can engage students. Rather than passively receiving information, students help generate information. Material is also paced to fit individuals' needs. Computerized study guides can improve students' overall level of mastery. Also, testing may be improved if students complete tests on computer screens and receive immediate feedback about their performance.

What educational benefits are gained by using CAI in psychology as a discipline and, more specifically, in introductory psychology? Only a few studies have investigated CAI in introductory psychology (e.g., Conn, Stafiniak, DiPasquale, & Harper, 1988; Welsh & Null, 1991), but several researchers have studied CAI as part of a course in experimental psychology (Chute, 1986; Goolkasian, 1989; Monahan, 1993; Perone, 1991; Petty & Rosen, 1990). Evaluation research in psychology outlines specific goals that CAI should produce. Outcome measures should include both learning and enjoyment components. In particular, we need to ask whether CAI experiences produce increased general learning in the course, learning of the concepts in which students completed exercises, enjoyment of the course, and enjoyment of the CAI experiences (Chute, 1986; Conn et al., 1988; Duncan, 1993; Isaacs, Costenbader, Reading-Brown, & Goodman, 1992; C. L. C. Kulik & J. A. Kulik, 1991; J. A. Kulik & C. L. C. Kulik, 1987; Lambert & Lenthall, 1989; McNeil & Nelson, 1991; Monahan, 1993; Niemiec & Walberg, 1987; Perone, 1991; Petty & Rosen, 1990; Ransdell, 1990).

Many design issues arise when evaluating the efficacy of CAI. One of the most pernicious is possible selection bias when comparing two classes that receive different treatments. After a thorough review of the literature, Duncan (1993) suggested participant variables that should be controlled: interest in the subject, prior knowledge of an area (Tobias, 1987), computer anxiety (Lambert & Lenthall, 1989), and generalized anxiety (Tobias, 1987). Trowbridge (1987), for example, took into account age, gender, grade point average (GPA), and family income. Liefeld and Herrmann (1990) controlled academic major, number of previous courses in the major, score on an English aptitude test, and semester GPA. Some researchers have matched groups for equality on critical variables. Underwood and Underwood (1987) matched groups on reading ability, IQ scores, and a pretest of ability to classify objects.

Duncan (1993) also articulated the controversy over the proper choice of dependent variable. Some argue for domain-specific measures, such as objective indices that focus on the concepts examined in CAI experiences (Duncan, 1991; Petty & Rosen, 1990; Welsh & Null, 1991). Others argue for more generalized measures of learning (Hannafin & Carney, 1991). Still others argue that student attitudes toward CAI or toward the specific software used in the class are proper dependent variables (Cordell, 1991; Duncan, 1991; Goolkasian, 1989; Lambert & Lenthall, 1989).

Our research responds to Duncan's (1993) methodological suggestions by examining the impact of CAI through the use of a quasi-experimental design (Cook & Campbell, 1979). To determine if students who complete CAI exercises in addition to attending traditional lectures outperform students who only attend lectures, two large sections of introductory psychology were matched on critical variables recommended by Duncan (1993), and CAI was incorporated into one of these sections.

The impact of CAI participation was assessed in several ways. First, students in both sections completed an identical final examination. All items on the final examination were covered in the lecture or the text; questions on material examined only in the CAI sections would have been unfair. However, some items on the final examination were also addressed by one CAI experience. The final examination, therefore, yielded two indices of student outcomes: overall examination score and examination score for CAI-supplemented items. The independent variable was the presence or absence of a weekly CAI session as a supplement to lecture. We predicted that students in the CAI section would outperform students in the no-CAI section.

Method

Participants

Participants attended Virginia Commonwealth University. They registered for introductory psychology without computer-assisted learning (no CAI; $n = 246$) or with computer-assisted learning (CAI; $n = 196$).

The instructor was a man who had taught introductory psychology for 18 years. CAI sections were conducted by two male graduate teaching assistants with one semester of experience conducting the sections before the semester in which the study was performed.

Procedure

We used a quasi-experimental design. Two sections of the course were offered in spring 1993. Students self-selected into sections through university registration procedures using a registration booklet that explained that one section was scheduled to meet an additional 50 min per week with a focus on CAI. Students in the no-CAI section did not complete the CAI exercises. At the beginning of the semester, research assistants collected demographic data from the university registrar to ensure that no systematic differences in demography between the CAI and no-CAI sections existed. Sections were matched on instructor, lecture, and textbook. The instructor gave the same lectures on the same days in each class, keeping a diary to note any differences that might affect student response to the lecture. In addition, each day of class, the instructor rated the relative response of students to lecture. The same textbook (Myers, 1992) was used in both sections.

In the second week of the semester, after the period for adding and dropping courses but before the first CAI 50-min session, students completed a demographic questionnaire with additional questions concerning students' attitudes toward and experience with computers and factors affecting their decision to enroll in the class with CAI or no CAI. Students in the CAI section rated the degree to which they expected to enjoy the CAI. All students completed a questionnaire in which they rated their preference for small, medium, and large classes.

A pre--postexperimental design was used to assess increases in learning over the course of the semester. An 18-question (fill-in-the-blank and short-answer) quiz was administered as a preliminary index of student knowledge of psychology. Students were told that this was part of an evaluation of learning in the class and were urged to do their best. Two forms of the quiz were used—one for each section—and the order was counterbalanced in the administration of the quiz at the end of the semester.

Students in the CAI section attended a 50-min class each week and completed one or more of the following types of computerized exercises: simulations of psychological processes, demonstrations of classic experiments, and tutorials. Simulations taught concepts such as hemispheric specializations, visual illusions, Piagetian conservation tasks, and statistical correlations. Several exercises demonstrated such classic experiments as Sperling's (1960) iconic memory study and Deutsch and Krauss's (1960) trucking game. Tutorials helped students understand processes such as neuron construction and functioning. Software used to provide these exercises was mostly PsychSim (Ludwig, 1986), which was available to the course instructor with Myers's (1992) text. Students in the CAI group performed two or three exercises per week. Students in the no-CAI group attended lectures only.

In the 3rd and 14th weeks of the course, the instructor audiotaped the same lecture in both classes. Those audiotapes were later rated for equivalence by listeners who were blind to section. At seven lectures throughout the semester, unannounced roll calls were taken to assess any differences between the two groups in student attendance at lectures.

In the 14th week of the course, the instructor administered (a) a quiz on course content (the counterbalanced version of the initial quiz), (b) institutionally mandated anonymous student evaluations of instruction to measure the perceived quality of the instructor and the course (Cordell, 1991; Duncan, 1991; Goolkasian, 1989; Lambert & Lenthall, 1989), and (c) a self-reported (nonanonymous) evaluation of the course on which students rated their enjoyment and the helpfulness of the course. All students who took the CAI class were asked, "Knowing what you do now that the semester is over, if you had it to do over again, and if you had a completely free choice without scheduling constraints, would you prefer this course with or without labs?" (Responses were coded as prefer with labs, mixed opinions or doesn't make any difference, or prefer without labs.)

During the same week, interviews with students from the CAI section were conducted. Seven students were selected at random from the students attending lectures in the CAI class and participated in a 20-min structured interview with the instructor. Items covered were as follows: (a) Tell me what you thought of the exercises. (b) Sometimes people race through the exercises without thinking; did you actually do the exercises or did you sometimes move quickly through them? (c) Did you use the study guide during the [CAI

50-min sessions]? (d) Which exercises (if any) did you particularly like? (e) Which (if any) did you dislike? (f) How did the exercises help (if the student had expressed that they had helped)? (g) Can you suggest anything that could be done differently with the [CAI 50-min sessions] that would help future students?

After the 15th week of the course, the same comprehensive final examination was administered to each section as a measure of generalized learning (Hannafin & Carney, 1991). (No other hourly examinations throughout the semester were the same.) Students had seen half the questions on the final examination; this half was drawn from a bank of 308 questions that students could study ahead of time. Of the 80 questions on the final exam, 15 critical items tested information covered in the CAI sessions (also covered in the book or lecture). Ten of the 15 critical items had not been seen previously, whereas 5 were in the question bank.

After the semester was completed and final grades had been submitted, students' presemester GPAs were obtained from university student records to use as a covariate in data analyses.

Results

Testing for Matched Sections

We tried to control some variables that may influence why people select one course over another. Demographic variables used to identify any systematic differences between sections included age, gender, and race (Trowbridge, 1987). The mean age for both classes was 22, and the standard deviation for both sections was 4. Specific data for gender and race are presented in Table 1. There was no difference in gender between the two groups, $\chi^2(1, N = 442) = .28$, $p > .05$. Similarly, race did not differ between the no-CAI and CAI classes; $\chi^2(4, N = 442) = 6.18$, $p > .05$.

Academic factors examined to test for matched groups included GPA (Duncan, 1993), class status (Tobias, 1987), reason for scheduling the course (Sawyer, 1988), and attrition rates (Duncan, 1993). Presemester GPA was used as a covariate in analyses. The 246 no-CAI students consisted of 112 freshmen, 60 sophomores, 33 juniors, 16 seniors, and 25 special students. Of the 196 CAI students, 108 were freshmen, 47 sophomores, 17 juniors, 3 seniors, and 21 special students. There was some difference in distribution of students by class status, $\chi^2(4, N = 442) = 10.49$, $p < .05$. The no-CAI section contained 45% freshmen, and the CAI class contained 55% freshmen.

Table 1. Demographic Comparisons Between No-CAI and CAI Groups

Variable	No-CAI		CAI	
	n	%	*n*	%
Gender				
Men	107	43	80	41
Women	139	57	116	59
Race				
African American	55	22	50	25
Native American Aborigines	3	1	2	1
Asian	20	8	7	4
Latino/Latina	7	3	2	1
Caucasian	161	65	135	69

We used a chi-square test to determine whether CAI or no-CAI students selectively took PSY 101 as a requirement or an elective. Of the 246 students in the no-CAI class, 123 reported taking the course because it was required, 80 took it as an elective, and 43 did not answer the question. Of the 196 students in the CAI class, 101 took the course because it was required, 63 took it as an elective, and 32 did not answer. There was no significant difference, $\chi^2(1, N = 442) = .04$, $p > .05$. The fraction of enrolled students who dropped the course was assessed by dividing the number of students who received grades at semester's end by the number of students enrolled in the class at the end of the first week (after add–drop week was complete). Of the 246 students in the no-CAI class at the end of the first week, 16 (6.5%) withdrew from the course before the official withdrawal date (halfway through the semester). Of the 196 students in the CAI class, 10 (5.3%) officially withdrew. There was no significant difference between classes in rates of withdrawal, $\chi^2(1, N = 442) = .39$, $p > .05$.

We also examined personal reasons that led students to choose one section over another, including the presence or absence of an additional CAI 50-min session of class, scheduling convenience, and preferred size of classes. An analysis of variance (ANOVA) revealed that scheduling convenience and preferred class size influenced students' choices in selecting either CAI or no-CAI sections. The no-CAI students were more likely to have chosen that section because it fit their schedule ($M = 4.0$, $SD = 1.1$) than were the CAI students ($M = 3.7$, $SD = 1.2$), $F(1, 387) = 6.15$, $p < .05$. Students who took the no-CAI class preferred larger class sizes than students who took the CAI classes, $\chi^2(3, N = 442) = 13.3$, $p < .01$. For the no-CAI class, 73 (30%) of the 246 students preferred small classes, 62 (25%) preferred moderate-size classes, 52 (21%) preferred large classes, 27 (11%) preferred very large classes, and 32 (13%) had missing data. For the CAI class, 83 (42%) of the 196 students preferred small classes, 53 (27%) preferred moderate-size classes, 23 (12%) preferred large classes, 12 (6%) preferred very large classes, and 25 (13%) had missing data.

Students' ratings of ability, comfort, and familiarity with computers did not differ between the two groups, all $ps > .05$. Overall, our tests for matching subjects between groups revealed that, although students self-selected into either the CAI groups or no-CAI, only class status and preference for class size differed between the two groups. The CAI group had significantly more freshmen than the no-CAI group; the CAI group preferred smaller classes, whereas the no-CAI group preferred larger classes. Demographic variables, academic factors, and attitudes toward computers did not differ between the two groups.

Validity Checks for Controlled Variables of Instructor and Lecture

Ideally, for good experimental control, by the end of the course students should have rated the instructor equally in both sections (Duncan, 1993; C. L. C. Kulik & J. A. Kulik, 1991). On the anonymous institutional evaluations of the instructor, students rated the instructor on a scale ranging from 1 (*poor*) to 5 (*outstanding*). In the no-CAI class, the mean rating was 4.2 ($SD = .8$); in the CAI class, the mean rating was 4.1 ($SD = .9$), $t(280) = 1.71$, $p > .05$.

Each day, the instructor rated the relative response of students to lecture. Class response was rated as equal for 14 lectures, CAI was better for 7 lectures, and no CAI was better for 8 lectures. Instructor-rated student response to lectures did not differ, $\chi^2(2, N = 442) = 2.99$, $p > .05$.

The same two lectures (from early and late parts of the semester) in each class were audiotaped and rated by listeners who were blind to the class. Relative ratings (When A and B were randomized, was Lecture A better, equal to, or worse than Lecture B?) were made by three undergraduate students not in the course to determine whether systematic differences (in content, lecture style, and audience participation) were apparent. No rater judged there to be any difference between the two lectures on any of the three dimensions.

Anonymous ratings of the course taken from the institutional student evaluations of instruction administered in the last 2 weeks of the course showed no difference between the no-CAI class ($M = 3.8$, $SD = .8$) and the CAI class ($M = 3.7$, $SD = 1.0$), $t(276) = .65$, $p > .05$.

Learning

Learning was assessed through difference scores on an 18-item pre–postquiz, comprehensive final examination scores, critical item scores (those final exam questions reflecting material covered not only in the lecture and text but also in the CAI sessions), and anonymous self-reports of learning. On the short-answer and fill-in-the-blank quiz, students answered a mean of .5 (no CAI) and .4 (CAI) of 18 questions correctly at pretest. At posttest, students answered a mean of 4.8 (no CAI) and 4.3 (CAI) questions correctly. There was no difference between no-CAI and CAI classes on mean recall learning, $F(1, 310) = .22$, $p > .05$.

The comprehensive final examination consisted of 80 multiple-choice questions. One technical problem was considered. Some students, usually those who were doing poorly in the class, did not take the final exam. Conceivably, differential attrition at the final exam by no-CAI and CAI students could influence the mean performance of the groups. Attrition before the final for no-CAI students (8.5% of those who had taken the other exams) did not differ from attrition before the final for CAI students (7.7%); thus, final exam scores for only the students taking the final exam were analyzed (no CAI, $n = 204$; CAI, $n = 168$). Of the 80 questions, the no-CAI students answered a mean of 54.6 questions correctly ($SD = 11.0$). The CAI students answered a mean of 57.8 questions correctly ($SD = 10.9$). A hierarchical multiple regression (on GPA, attendance, and class) was used to determine whether class affected score on the final exam. First, initial GPA was entered. Second, we entered the number of student absences obtained from unannounced roll calls taken at seven randomly selected lectures. Finally, class (no CAI or CAI) was entered. Means

Table 2. Means and Standard Deviations for Important Variables

Variable	No-CAI *M*	No-CAI *SD*	CAI *M*	CAI *SD*
Final exam[a]*	54.6	11.0	57.8	10.9
Critical items (final exam)[b]*	8.3	2.7	10.2	2.3
Initial GPA[c]	2.4	.9	2.5	.8
Attendance at lecture[d]	6.1	1.7	6.0	2.3
Familiarity with computers[e]	2.9	.9	2.9	1.0
Comfortable with computers[e]	3.1	1.0	3.2	1.2
Experience with computers[e]	2.5	.9	2.5	1.1
Fit schedule[e]	4.0	1.1	3.7	1.2

[a]Mean number of multiple-choice items correct of 80 items. [b]Mean number of items correct of 15 items. [c]GPA based on courses taken at Virginia Commonwealth University on a 4.00 system. [d]Number of times present in lecture during 7 unannounced roll calls. [e]Rated on a scale ranging from 1 (*not at all*) to 5 (*extremely*).
*$p < .01$.

and standard deviations for each variable are given in Table 2. Initial GPA significantly predicted score on the final exam, $R^2 = .48$, $F(1, 370) = 338.7$, $p < .001$. Frequency of attendance at lecture did not significantly affect final exam score, R^2 change $= .00$, $F(2, 369) = 3.6$, $p > .05$. Even after controlling for initial GPA and attendance, class type predicted final exam score, R^2 change $= .01$, $F(3, 368) = 7.3$, $p < .01$.

Final exams contained 15 critical questions that were covered in the CAI exercises as well as in the book or lecture. Those questions were analyzed separately from questions covered only in the readings or the lectures (Duncan, 1991; Petty & Rosen, 1990; Welsh & Null, 1991). A hierarchical multiple regression was used to determine whether class type affected score on the 15 critical items. Students in the no-CAI class answered a mean of 8.3 correctly ($SD = 2.7$), and students in the CAI classes answered a mean of 10.2 correctly ($SD = 2.3$). The predictor variables were entered in the same order as in the previous analysis. Initial GPA significantly predicted score on the critical items, $R^2 = .32$, $F(1, 370) = 171.5$, $p < .001$. Once again, attendance at lecture did not significantly affect critical item score, R^2 change $= .00$, $F(2, 369) = 1.1$, $p > .05$. Even after controlling for initial GPA and attendance, class type predicted critical item score, R^2 change $= .09$, $F(3, 368) = 56.3$, $p < .001$.

Taken together, analyses of the final examination scores and the 15 critical items suggest that the critical item score made a difference in final exam scores between the no-CAI and CAI groups. As a post hoc analysis, we tested the predictive value of CAI after removing the critical items from final examination scores. Predictor variables of including GPA, attendance, and class were entered into a hierarchical multiple regression analysis. Using a modified final examination score, after removing the variance from GPA and attendance at lecture (as in previous analyses), class type did not predict modified final examination scores, R^2 change $= .006$, $F(3, 359) = 1.279$, $p > .05$. In sum, the predictive value of CAI disappeared when the critical item score was removed from the final examination score. The critical item score from items covered in the text, lecture, and CAI sessions made the difference in final examination scores.

Students in no-CAI and CAI classes did not differ in their anonymous ratings of self-reported learning. Both rated learning 3.6, $t(278) = .01$, $p > .05$.

Post Hoc Analysis

Because preference for size of class differed for students who took the CAI versus the no-CAI class, we conducted an attribute-by-treatment analysis. Students were divided into those who preferred small, moderate-size, large, and very large classes. Preference for class size was crossed with class type (no CAI and CAI). We hypothesized that students preferring smaller classes would perform better in the CAI class and students preferring larger classes would perform better in the no-CAI class. A 4 × 2 (Preferred Class Size × Class) ANOVA with final exam score as the dependent variable revealed that the main effect for class was significant, $F(1, 332) = 7.10$, $p < .01$, but neither the main effect for preference for class size, $F(3, 332) = .81$, $p > .05$, nor the interaction, $F(3, 332) = .09$, $p > .05$, was significant. A 4 × 2 (Preferred Class Size × Class) ANOVA with number of critical items answered correctly on the final exam as the dependent variable showed that the main effect for class was significant, $F(1, 332) = 40.74$, $p < .001$, but neither the main effect for preference for class size, $F(3, 332) = 1.81$, $p > .05$, nor the interaction, $F(3, 332) = .23$, $p > .05$, was significant.

Supplemental Analyses: Responses of Students Who Took the CAI Class

For students in the CAI class, correlations were calculated for the precourse expectations about liking computerized exercises, end-of-course ratings of the degree to which students found the CAI enjoyable and helpful, score on the final exam, and score on the 15 critical items (see Table 3).

Precourse expectations that students would like computerized exercises were unrelated to later ratings of enjoyment or helpfulness and to measures of learning. End-of-course ratings of enjoyment and helpfulness were related to each other but were unrelated to learning. Measures of learning were related to each other but not to subjective ratings of expectation, enjoyment, or helpfulness of the CAI exercises.

Table 3. Correlation Matrix for Expectations About CAI, Ratings of Enjoyment and Helpfulness of CAI, and Performance on Measures of Learning

	Expect (1)	Enjoy (2)	Help (3)	Final Exam (4)	Critical (5)
1	1.00				
2	.02	1.00			
3	.05	.92*	1.00		
4	.07	.02	.05	1.00	
5	.05	-.02	.04	.75*	1.00

Note. Expect = precourse expectations that students would enjoy the CAI exercises, 1 (*not at all*) to 5 (*extremely*); Enjoy = end-of-course ratings of whether students enjoyed the CAI exercises, 1 (*extremely unenjoyable*) to 7 (*extremely enjoyable*); Help = end-of-course ratings of whether students found the CAI exercises helpful, 1 (*extremely unhelpful*) to 7 (*extremely helpful*); Final Exam = score (number correct of 80 questions) on the final exam; Critical = number of items answered correctly of the 15 critical items.
*$p < .01$.

Students who took the CAI class responded to the stimulus: Knowing what you do now that the semester is over, if you had it to do over again, and if you had a completely free choice without scheduling constraints, would you prefer this course with or without (CAI) labs? Of the 163 who responded, 106 (65%) said they preferred the class with CAI; 25 (15%) had mixed opinions or said it did not make any difference; 32 (20%) preferred the class without CAI.

Structured Interviews

Seven students were selected at random from the CAI class and participated in a 20-min structured interview with the instructor. The interview covered the following points.

(a) Tell me what you thought of the exercises. All seven expressed positive reactions to the exercises; two confessed to initial negative reactions to having to spend an extra 50 min each week, but both said that after the course, they were glad to have had the exercises.

(b) Sometimes people race through the exercises without thinking; did you actually do the exercises or did you sometimes move quickly through them? All seven professed taking the exercises seriously.

(c) Did you use the study guide during the [CAI sessions]? Four of the seven students said they used the study guide regularly; two said they used it once or twice; one never used it.

(d) Which exercises did you particularly like? Most liked exercises on perception and memory. Three liked the exercise on the neuron. One liked the exercise on Piaget.

(e) Which did you dislike? One disliked the Piaget exercise. Two disliked all exercises that made the students read a lot and did not involve them in activities.

(f) How did the exercises help [if the student had expressed that they had helped]? Students expressed various reasons for the helpfulness of the exercises, including creating interest, helping review, and reinforcing lecture by looking at the material in a different way.

(g) Can you suggest anything that could be done differently with the [CAI sessions] that would help future students? Some suggested increasing the length of the CAI sessions so students would have more time to use study guides and having more quizzes. One suggested emphasizing the same topics in lecture that were emphasized in the CAI session.

Discussion

CAI exercises, as a supplement to traditional lecture, produced additional learning in an introductory psychology class. Students neither differentially withdrew from the class after beginning the CAI sections nor did they differentially fail to take the final exam (due to grades that were so low that the course could not be passed even with good performance on the examination).

In testing the effectiveness of CAI, several variables were controlled—more variables than previous research has considered. We examined student characteristics (age, gender, and race), class status, whether the course was required or taken as an elective, experience with computers, and variables concerning reasons for taking the course (see Duncan, 1993). Of those, only the variables concerning reasons for taking the class differed between the two classes. For example, students did not elect the CAI or no-CAI class because of the presence or absence of CAI per se, but they chose one class over the other because of the fit with their schedule or their preferred size of class. Results of an Attribute × Treatment (Preferred Class Size × Class) analysis revealed that presemester preferences for class size did not affect performance on the final exam as a whole or on the critical items covered in the CAI exercises. This finding supports the results of C. L. C. Kulik and J. A. Kulik's (1991) meta-analysis of 254 controlled studies that examined student attribute-by-treatment comparisons. Similar conclusions were reached after qualitative reviews of the literature by Duncan (1993) and Ransdell (1993).

Initial GPA predicted performance on the final examination, but higher attendance at lectures did not. This effect can be explained by the fact that, after the critical items were removed from the final examination, no differences in performance between the groups were detected. The groups differed according to those areas that not only were discussed in lecture but also were reinforced during the computer sessions. Even after controlling for GPA and attendance, exposure to CAI resulted in higher performance on the final examination, although only 1% of the variance was accounted for by the CAI exercises. Similar findings were obtained when performance on critical items was used as the dependent variable, but only 9% of the variance was accounted for by participation in the CAI exercises. In the CAI class, students spent 3.5 hr per week of classroom activity (performing exercises and demonstrations, reviewing the study guide, and taking six short multiple-choice quizzes on the material covered in the course) rather than 2.67 hr per week with the no-CAI class. Gains from participating in CAI exercises were modest.

Extra time spent on the study guide and quizzes may have accounted for better performance of students in the CAI class on the final examination, but this is unlikely. Most students in the no-CAI class purchased written study guides, which included the same material that was available in CAI. By identifying test items as either general material or critical items representing CAI domain-specific information, we were able to determine whether additional class time spent doing CAI increased overall learning or domain-specific learning. Essentially all of the increased performance was attributable to domain-specific performance on the items covered in the CAI exercises. Students in the CAI class, on average, answered three more questions correctly than did students in the no-CAI class; however, students in the CAI class correctly answered two more of the critical items covered in the CAI exercises. This result suggests that it was not additional time spent reviewing the study guide, taking quizzes, or mere additional time dealing with the content of the course that affected performance. Rather, the time spent completing the specific exercises translated into gains in learning that material; this is congruent with Castellan's (1993) study.

Most students who completed the class were positive toward the experience, as revealed by the supplemental analyses and the structured interviews. Positive reactions to the CAI exercises, better performance on the final examination, and better performance on critical items could not be accounted for by expectations before the course. Furthermore, positive reactions to the exercises were unrelated to performance on the examination or the critical items. These findings suggest that CAI allows people to learn, assuming they participate in the exercises, regardless of whether the students enjoy the exercises.

Our results offer modest support for including CAI exercises as a supplement to traditional lectures in introductory psychology (Conn et al., 1988; Welsh & Null, 1991). However, the gains in knowledge were limited to the content covered in the particular exercises used in the CAI sessions. We did not test whether a similar review or discussion session offered to the no-CAI group would have increased learning for those students with no access to computerized assistance. Although such alternatives to CAI have been shown to increase knowledge, computerized exercises have been shown to increase learning in significantly less time with fewer staff resources (Welsh & Null, 1991). Learning is domain specific, and software must be chosen with this in mind. CAI can increase learning in introductory psychology, but it cannot improve knowledge it did not cover.

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Note

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An Interdisciplinary, Computer-Centered Approach to Active Learning

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This article describes a computer-assisted, interdisciplinary course in decision making developed to promote student participation, critical thinking, and enhanced decision making through the use of interactive experimental paradigms. The course uses Macintosh computers for simple data entry and presentation, for more complex calculations and extended graphics, and for stimulus presentation and data collection. Students experience firsthand 20 psychology and economics exercises that illustrate a range of biases and heuristics known to affect decision making and that allow for examination and evaluation of students' decision-making tactics.

Active learning and computer-assisted instruction (CAI) are frequently discussed in academia. This article describes a university course, Studies in Decision Making, that combines psychology and economics in a team-taught, interdis-