DOCUMENT RESUME

ED 263 890 IR 011 876

AUTHOR Kulik, Chen-Lin C.; Kulik, James A.
TITLE Effectiveness of Computer-Based Education in Colleges.
PUB DATE Mar 85
NOTE 50p.; Paper presented at the Annual Meeting of the American Educational Research Association (69th, Chicago, IL, March 31-April 4, 1985). Tables 2 and 4 contain small print. For a related document, see IR 011 874.
PUB TYPE Information Analyses (070) -- Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; *College Students; *Computer Assisted Instruction; Higher Education; Individualized Instruction; Instructional Innovation; Literature Reviews; *Meta Analysis; Online Systems; Research Methodology; Student Attitudes; Teaching Methods; Time Factors (Learning)
IDENTIFIERS *Instructional Effectiveness

ABSTRACT

The 101 computer-based education (CBE) studies considered for use in this meta-analysis came from three major sources: references in an earlier meta-analytic review of CBE at the college level (J. Kulik, et al., 1980); a computer search of the Comprehensive Dissertation Abstracts and ERIC databases; and utilization of the bibliographies contained within the documents located through reviews and computer searches. The instructional outcome measured most often in the 101 studies was student learning as indicated on achievement examinations given at the end of a program of instruction. Some additional outcome variables measured included: performance on a follow-up or retention examination at a later date; attitudes toward computers; course completion; and amount of time needed for instruction. Findings indicate that computer-based education usually has positive effects on college students (CBE raised student examination scores by 0.26 standard deviations in the average study); CBE effects were somewhat lower in unpublished studies than they were in published reports; CBE effects were also somewhat lower in the hard, nonlife sciences than in the social and life sciences and education; CBE produced small but positive changes in student attitudes toward instruction and computers; and CBE also reduced substantially the amount of time needed for instruction. A 12-page reference list and 4 tables complete the document. (Author/JB)

Effectiveness of Computer-Based Education In Colleges

Chen-Lin C. Kulik & James A. Kulik

Center for Research on Learning and Teaching
The University of Michigan

A presentation at the annual meeting of the American Educational Research Association, Chicago, March 1985

Abstract

A meta-analysis of findings from 101 controlled evaluations showed that computer-based education (CBE) usually has positive effects on college students. CBE raised student examination scores by 0.26 standard deviations in the average study--a small but significant effect. CBE effects were somewhat lower in unpublished studies than they were in published ones, and they were also somewhat lower in the hard, nonlife sciences than in the social and life sciences and education. In addition, CBE produced small but positive changes in student attitudes toward instruction and computers. Finally, CBE also reduced substantially the amount of time needed for instruction.

Effectiveness of Computer-Based Education In Colleges

Over the centuries technological advances have had a profound impact on education. The development of writing, for example, liberated education from oral tradition and greatly reduced the need for learners to memorize vast quantities of information. The development of printing had equally important effects on education. It opened up libraries of new information for teachers and students and greatly increased educational efficiency.

Some social commentators are now predicting that computer technology will change education in the years ahead as completely as the invention of writing and printing did in centuries past. Researchers long ago demonstrated that computers can work in schools as drill masters, tutors, testers, and diagnosticians of educational problems. But until recently the cost of computer-based teaching systems stood in the way of wide-scale use. With the development of small, quick, inexpensive microcomputers during the last decade, computing costs have dropped dramatically, and a computer revolution in education has become a real possibility.

College teachers have already begun to feel the force of the computer's impact. Twenty years ago, computer terminals made their way into research laboratories and changed the way that college researchers analyzed their data. Ten years ago, computers found their way into college offices and changed the writing habits of many teachers. Today, microcomputers are coming into the classroom, and they are changing the way that college teachers teach and college students learn.

The roots of this computer revolution in teaching stretch back nearly 30 years to the invention of the Skinnerian teaching machine. In his 1954 article "The Science of Learning and the Art of Teaching," the psychologist B. F. Skinner argued that machines could teach more reliably and effectively than human teachers do. They could present lessons in a sequence of small steps, wait patiently for the learner's response at each step, and reinforce each response immediately. Programmed machines, Skinner believed, could make teaching more effective and learning more joyful.

A second landmark in the technological revolution came a few years later with the development of individualized <u>systems</u> of instruction. Like Skinnerian programmed instruction, these individualized systems emphasized independent, self-paced work with print materials, but individualized systems used longer instructional units--often called learning activity packages or modules--that gave learners more freedom to choose among different means of learning. An especially important feature in these systems was the requirement that all learners demonstrate their mastery of each unit of material on repeatable unit-mastery tests. Individually Prescribed Instruction, Project Plan, Individually Guided Education, and Keller's Personalized System of Instruction are probably the best known of the individualized systems developed during the 1960s (J. Kulik, 1983).

The third stage in this technological revolution was marked by the development of computer-based education (CBE). In early applications, the computer simply delivered programmed instruction and managed individualized teaching systems. The marriage of computer technology and programmed instruction came to be known as computer-assisted instruction (CAI); the marriage of computer technology and individualized systems produced computer-managed instruction (CMI). More recently, computers have been used for more sophisticated teaching jobs. They have served as tools in mathematics and writing classes and as simulation devices in classes in the natural and social sciences. Some educators now argue that students learn most from computers when they are used in this way to provide computer-enriched instruction (CEI).

The educational revolutions based on writing and printing ran their course without any help from educational research. No one tried to measure educational outcomes while these revolutions were in progress. Scientific tools for measuring, predicting, and controlling social events were unavailable. The computer revolution is different. It is occurring at a time when we have tools for evaluating specific programs and tools for drawing general conclusions from a collection of specific evaluations.

These tools have already been used to evaluate CBE effects. In a typical evaluation study, a researcher divides a class of students into an experimental and a control group. Members of the experimental group receive part of their instruction at computer terminals, whereas students in the control group receive their instruction by conventional methods. At the end of the experiment, the researcher compares responses of the two groups on a common examination or on a course evaluation form. Such evaluation studies have been carried out often enough to give some indication of the overall worth of CBE in college teaching.

Reviews designed to integrate the findings from the evaluation studies are of two basic types: narrative accounts and meta-analyses. Narrative reviewers usually provide concise summaries of major studies and often draw conclusions about overall effects based on these studies. Reviewers using meta-analysis take a more quantitative approach to evaluation results (Glass, McGaw, & Smith, 1981). They use (a) objective procedures to locate studies; (b) quantitative or quasi-quantitative techniques to describe study features and outcomes; and (c) statistical methods to summarize overall findings and explore relationships between study features and outcomes.

Narrative reviews have seldom reported dramatic educational advantages from computer-based instruction at higher levels of education. Jamison, Suppes, and Wells (1974), for example, reviewed nearly a dozen small-scale studies of CBE in college classrooms. Most of these studies were carried out in courses operated as part of research and development projects in computer-assisted instruction. Jamison and his colleagues reported that the results of the studies defied easy summary. Computer-assisted instruction appeared to be about as effective as traditional instruction, they finally concluded, but they also pointed out that most alternative methods of instruction appear to be about as good as conventional teaching at the college level.

Kulik, Kulik, and Cohen (1980) carried out a major meta-analytic synthesis of evaluation findings on CBE at the college level. Their review integrated results from 59 independent evaluations. The meta-analysis showed that CBE made small but significant contributions to students' academic achievement and also produced positive, but again small, effects on student attitudes. In addition, CBE also reduced substantially the amount of time needed for instruction. In general, Kulik and his colleagues found little relationship between study findings and design features of evaluations, settings for the evaluation, or manner and date of publication of the findings.

The value of reviews such as these is limited by at least two factors. First, the reviews do not cover recent applications of the computer in college teaching. None of the studies reviewed by Jamison et al. (1974), for example, was published after 1972; none of the studies reviewed by Kulik et al. (1980) was published after 1978. Computers have changed dramatically since that time. They have become smaller, less expensive, more reliable, and quicker in their operations. Communication with them has become easier, and their output has become more readable and attractive. These developments have influenced not only the ways in which computers are being used in college teaching today, but also the subject areas to which they are being applied.

A second factor that limits the value of earlier reviews is their methodology. Early reviews of CBE effectiveness were written at a time when rapid progress was being made in the development of a methodology for research synthesis. Even the quantitative syntheses, for example, did not incorporate the most recent advances in meta-analytic methodology. Early users of meta-analysis, for example, were often unselective in choosing their studies; they often inflated sample sizes by using nonindependent findings in a single statistical analysis; and they often reported their results in a sketchy fashion (J. Kulik, 1984). Today's meta-analysts try to avoid these methodological flaws.

This review is meant to supplement earlier reviews on the effectiveness of CBE at the college level. It updates these reviews and uses currently accepted methods for integrating and reporting evaluation findings. The article asks questions such as these: How effective is CBE at the college level? Is it especially effective for certain types of outcomes or certain types of students? Under which conditions does CBE appear to be most effective?

Method

The meta-analytic approach used in this review is similar to that described by Glass, McGaw, and Smith (1981). Their approach requires a reviewer (a) to locate studies of an issue through objective and replicable searches; (b) to code the studies for salient features; (c) to code study outcomes on a common scale; and (d) to use statistical methods to relate study features to outcomes.

Data Sources

The studies considered for use in this meta-analysis came from three major sources. One large group of studies came from the references in our earlier meta-analytic review of CBE at the college level (J. Kulik et al., 1980). A second group of studies was located by computer-searching two library data bases using Lockheed's Dialog Online Information Services. The data bases searched in this way were (a) Comprehensive Dissertation Abstracts, and (b) ERIC, a database on educational materials from the Educational Resources Information Center, consisting of the two files Research in Education and Current Index to Journals in Education. A third group of studies was retrieved by branching from bibliographies in the documents located through reviews and computer searches.

These search procedures yielded 101 studies that met four basic criteria for inclusion in our data set. First, the studies had to take place in actual college classrooms.

They had to involve real teaching, not an analog of teaching. Second, the studies had to provide quantitative results on an outcome variable measured in the same way in both a computer-taught and a conventionally instructed class. Uncontrolled "experiments" and anecdotal reports were not acceptable. Third, the studies had to be free from such crippling methodological flaws as (a) substantial differences in aptitude of treatment and control groups, (b) unfair "teaching" of the criterion test to one of the comparison groups, and (c) differential rates of subject attrition from the groups being compared. And fourth, the studies had to be retrievable from university or college libraries by interlibrary loan or from the Educational Resources Information Center, the National Technical Information Service, or University Microfilms International.

These standards kept us from using 6 of the 59 reports cited in our earlier reviews (1980). (a) One study (Ozarowski, 1973) was eliminated because it covered nontraditional adult education rather than college teaching. (b) Another study was eliminated because it did not include results from a conventionally instructed control group (Gallagher, 1972). (c) Arsenty and Kieffer's (1971) study was eliminated because it did not report results on an objectively measured criterion; only teacher assigned grades were examined. (d) Three studies were not used in this analysis because their report of results was insufficient for the calculation of size of effect (Dudley, Elledge, & Mukherjee, 1974; Hsiao, 1973; and Kromhout, Edwards, & Schwarz, 1969).

Outcome Measures

The instructional outcome measured most often in the 101 studies was student learning, as indicated on achievement examinations given at the end of the program of instruction. Other outcome variables measured in the studies were the following: (a) performance on a follow-up or retention examination given some time after the completion of the program of instruction; (b) attitude toward computers; (c) attitude toward instruction; (d) attitude toward school subjects; (e) course completion; and (f) amount of time needed for instruction.

For statistical analysis, outcomes had to be expressed on a common scale of measurement. The transformation used for this purpose was the one recommended by Glass et al. (1981). Like Glass and his colleagues, we coded each outcome as an Effect Size (ES), defined as the difference between the mean scores of two groups divided by the standard deviation of the control group. For studies that reported means and standard deviations for both experimental and control groups, ES could be calculated directly from the measurements provided. For less fully reported studies, ES could usually be calculated from statistics such as t and F.

The application of the formulas given by Glass and his colleagues was straightforward in most cases. In some studies, however, more than one value was available for use in the numerator of the formula for ES and more than one value was available for the denominator. For example, some investigators reported raw-score differences between groups as well as covariance-adjusted differences, and some reported differences on a post-measure as well as differences in pre-post gains. In such cases, we used as the numerator of ES the difference that gave the most accurate estimate of the true treatment effect. That meant using covariance-adjusted differences rather than raw-score differences, and differences in gains rather than differences on posttests. In addition, some reports contained several measures of variation that might be considered for use as the denominator of ES. We use the measure that provided the best estimate of the unrestricted population variation in the criterion variable.

For measurement of the size of CBE effects on course completion, we used the statistic h (Cohen, 1977). This statistic is appropriate for use when proportions are being compared. It is defined as the difference between the arcsine transformation of proportions associated with the experimental and control groups. To code CBE effects on instructional time, we used a ratio of two measurements: the instructional time required by the experimental group divided by the instructional time required by the control group.

Study Features

A total of 17 variables were used to describe treatments, methodologies, settings, and publication histories of the studies (Table 1). These 17 variables were chosen on the basis of (a) an examination of variables used to describe study features in previous reviews, and (b) a preliminary examination of dimensions of variations in the studies located for this analysis. Two coders independently coded each of the studies on each of the variables. The coders then jointly reviewed their coding forms and discussed any disagreements. They resolved these disagreements by jointly reexamining the studies whose coding was in dispute.

Insert Table 1 about here

Unit of Statistical Analysis

Some studies reported more than one finding for a given outcome area. Such findings sometimes resulted from the use of more than one experimental or control group in a single study, and they sometimes resulted from the use of several subscales and subgroups to measure a single outcome. Using several ESs to represent results from one outcome area of one study seemed to be inappropriate to us because the ESs were usually nonindependent. They often came from a single group of subjects or from overlapping subject groups, and they almost always represented the effects of a single program implemented in a single setting. To represent a single outcome by several ESs would violate the assumption of independence necessary for many statistical tests and would also give undue weight to studies with multiple groups and multiple scales.

The procedure that we adopted, therefore, was to calculate only one ES for each outcome area of each study. A single rule helped us to decide which ES best represented the study's findings. The rule was to use the ES from what would ordinarily be considered the most methodologically sound comparison when comparisons differed in methodological adequacy. (a) When results from both a true experimental comparison and a quasi-experiment were available from the same study, results of the true experiment were recorded. (b) When results from a long and short CBE implementation were available, results from the longer implementation were used. (c) When transfer effects of CBE were measured in addition to effects in the area of instruction, the direct effects were coded for the analysis. (d) In all other cases, our procedure was to use total score and total group results rather than subscore and subgroup results in calculating ES.

Results

Because most of the studies in the pool investigated effects of CBE on examination performance, we were able to carry out a complete statistical analysis of results in this area. The analysis covered both average effects and the relationship between effects and study features. We carried carried out less complete statistical analyses of other outcome areas because of the limited number of studies in these areas.

Examination Performance

A total of 99 of the 101 studies in our pool reported results from CBE and control groups on an examination given at the end of instruction (Table 2). In 77 of the 99 studies, the students in the CBE class had the higher examination average; in 22 studies the students in the conventionally taught class had the higher average. The difference in examination performance of CBE and control students was reported to be significant in 22 studies. In 21 of the 22 cases, the significant difference favored the CBE class, whereas only one study favored conventional teaching. Overall, these box-score results favor CBE.

Insert Table 2 about here

The index ES provides a more exact picture of the degree of benefit from CBE in the typical study. The average ES in the 99 studies was 0.26; its standard error was 0.051. This average ES means that in the typical study, the performance of CBE students was 0.26 standard deviations higher than the performance of the control students. ESs can also be expressed in terms of percentile scores. Approximately 60% of the area of the standard normal curve falls below a z-score of 0.26. We can conclude, therefore, that the typical student in an average CBE class would perform at the 60th percentile on an achievement examination, whereas the typical student in a conventionally taught class would perform at the 50th percentile on the same examination. Put in another way, the average student from the CBE class would outperform 60% of the students from the conventional classes.

Examination Performance and Study Features

Although the increase in examination performance attributable to the computer was moderate in the typical study, effects varied in magnitude from study to study. The strongest positive result reported was an effect of 2.17 standard deviations (Cartwright, Cartwright, & Robine, 1972); the strongest negative result was an effect of -1.20 standard deviations (Diem, 1982). It seemed possible that this variation in study outcome might be systematic, and further analyses were conducted to determine whether different types of studies were in fact producing different results. Three study features proved to be significantly related to achievement ES (Table 3). Average ES differed in studies that came from (a) different publication sources, (b) disciplines with different degrees of emphasis on scientific methodology; and (c) disciplines with different degrees of emphasis on life versus nonlife processes.

Insert Table 3 about here

Publication sources. The average ES in studies found in professional journals was significantly higher than was the average effect in studies found in dissertations and technical documents, F (2,96) = 3.49, $p < .05$. The average ES in the 41 journal studies was 0.42 (SE = .08); it was 0.16 (SE = 0.07) in the 46 dissertation studies; and it was 0.11 (SE = 0.14) in the 12 technical reports. The difference between results found in dissertation studies and those found in technical documents was too small to be considered statistically significant, but the difference in results from journals and from other sources was significant.

Course content. The average ES from courses in the hard sciences was significantly lower than the average ES from the soft disciplines, F (1,97) = 4.16, $p < .04$. The average ES in the 44 studies of CBE applications in the hard scientific disciplines was 0.15; it was 0.35 for the 55 studies of applications in the social sciences and humanities. The average ES from courses emphasizing life processes was also significantly higher than was the average ES from courses emphasizing nonlife content, F (1,97) = 9.15, $p < .01$. The average ES in the 22 studies of life courses was 0.54; it was 0.18 in the 77 studies of nonlife courses. The coding on these two dimensions of course content, however, was significantly correlated, $r = .29$, $p < .01$.

Other Effects

A total of 52 of the 101 studies examined outcomes of CBE in areas other than examination performance. Findings for these other outcomes appear in Table 4.

Insert Table 4 about here

Retention tests. Six studies examined the performance on follow-up examinations of CBE and conventionally taught classes. The follow-up interval in these studies varied from 2 to 10 weeks. The six studies did not seem to be representative of the total pool of studies. Whereas the average ES on course examinations was 0.26 for all 99 studies, the average ES on final examinations for these six studies was only 0.02. It would be risky, therefore, to draw any general conclusions from these six studies. The average retention ES in the six studies was 0.18 (SE = 0.07).

Attitudes toward computers. Eleven studies examined students' attitudes toward computers. Contact with the computer in many of the studies produced positive changes in students' attitudes, and 7 of the 11 studies reported more favorable attitudes for students in the CBE class. The average ES in the 11 studies was 0.27 (SE = 0.16).

Attitudes toward instruction. Thirteen studies examined student ratings of the quality of instruction. Nine of the 13 studies found more positive attitudes in the CBE class; 1 study found no difference in attitudes for CBE and conventionally taught classes; and 3 studies found more negative attitudes in the CBE class. The average ES in the 13 studies was 0.31 (SE = 0.13).

Attitude toward subject. Fifteen studies examined the effects of CBE on student attitudes toward the subject matter that they were being taught. Only six of the 15 studies reported that student attitudes in CBE classes were more positive than in conventional classes; nine studies found negative effects. The average ES for student attitudes toward instruction was -0.03 (SE = 0.07), a very small negative effect.

Course completion. Twenty-one studies compared the numbers of students completing CBE and conventional classes. Eight of these 21 studies found higher completion rates in the CBE class; and thirteen studies found higher completion rates in the control class. The average h for attrition for these 21 studies was -0.08 (SE = 0.060), a very small effect favoring the control class.

Instructional time. Fifteen studies compared the instructional time for students in the CBE and conventional classrooms. The ratio of instructional time for CBE students to instructional time for students studying conventionally was 0.66 in the average study. In other words, CBE students required only two-thirds as much instructional time as did students who were taught conventionally. The range of ratios varied from .38 to .97, but in no case did the conventionally taught class require more instructional time than the CBE class.

Discussion

This meta-analysis showed that college-level CBE has basically positive effects on students. It raised final examination scores in the typical study by 0.26 standard deviations, or from the 50th to the 60th percentile. This figure is very close to the average effect size of 0.25 reported in our earlier meta-analysis of findings from 59 studies of college level CBE (J. Kulik, Kulik, & Cohen, 1980). The figure is also identical to the average effect size for CBE on achievement at the secondary level (Bangert-Drowns, Kulik, & Kulik, 1985), but it is smaller than the average effect size of 0.42 for CBE at the elementary level (C. Kulik, Kulik, & Bangert-Drowns, 1984).

This analysis did not find any significant difference in effectiveness for different types of CBE implementations. CAI, CMI, and CEI programs all made small, positive contributions to student learning. This result is strikingly different from precollege findings on CBE. In elementary schools, for example, CAI programs of drill and practice and tutorial instruction almost always produced good results, whereas CMI programs produced much weaker findings (C. Kulik et al., 1984). In high schools, both CAI and CMI produced positive results, but CEI programs contributed little to student achievement (Bangert-Drowns et al., 1985). At the college level, students seem to be able to adapt to a variety of uses of the computer in teaching.

The relationship between study features and study outcomes was not strong in this meta-analysis. Design features of experiments, for example, did not influence outcomes. Quasi-experimental studies and true experiments produced similar results. Experiments with controls for historical effects yielded the same results as experiments without historical controls. Such findings were not surprising to us. They have emerged repeatedly in meta-analyses of findings from educational research.

Publication source of a study, however, was significantly related to study outcome. Results found in journal articles were clearly more positive than were results from dissertations and technical documents. The difference in effects from these different sources was not only highly significant, but it was also highly predictable. A difference between journal and dissertation results has been reported in numerous quantitative syntheses of research and evaluation findings (Bangert-Drowns et al., 1984; Glass et al., 1981, pp. 64-68). The relationship is one of the best documented findings in the meta-analytic literature.

The factors that produce this difference, however, are not completely understood. A number of writers have attributed the difference in journal and dissertation findings to publication bias (e.g., Clark, in press). This is the purported tendency of researchers, reviewers, and editors to screen reports for publication on the basis of size and statistical significance of effects, rather than on the basis of study quality. Such publication bias would make journals an unreliable source for information about the effectiveness of experimental treatments. Other writers have noted that journal studies and other studies are carried out by different persons working under different conditions (e.g., J. Kulik, Kulik, & Bangert-Drowns, in press). The typical author of a journal article, for example, differs from the typical dissertation writer in research experience, resources, professional status, and many other respects. If the weakness of dissertation results is attributable to the inexperience of dissertation writers, then dissertations would be a poor source for information on the effectiveness of treatments.

Strength of results was also a function of the content area in which the CBE evaluation was carried out. Effects of CBE were less clear in disciplines emphasizing hard science and nonlife studies; effects were clearer in disciplines emphasizing life studies and a softer, less scientifically rigorous approach; typical of disciplines with less clear effects are mathematics, chemistry, physics, and engineering. Typical of disciplines with clearer effects are the social sciences. A similar relationship between size of effect and discipline area of the study has been found in other quantitative syntheses of college level findings (C. Kulik, Kulik, & Cohen, 1980).

The factors that produced this relationship--like the factors behind the relationship of publication source to effect size--are not yet fully understood. It is possible, on the one hand, that findings from social science courses are stronger because the quality of evaluation studies is better in the social sciences. Most evaluations from the social sciences are produced by evaluators with a strong background in and a professional identification with behavioral measurement. Other explanations of this result are also possible, however. Instruction in the hard, nonlife sciences may be more difficult to improve because students in these areas may already be achieving at or near their maximum. Or teachers in the social sciences may be more discerning in their use of CBE than are teachers in the natural sciences.

Another important finding in this meta-analysis was the reduction in instructional time associated with CBE. In each of the 15 studies that reported results on instructional time, the computer did its job quickly--on the average in about two-thirds the time required by conventional teaching methods. It is clear therefore that the computer can function satisfactorily in college courses and at the same time reduce time spent in instruction. In addition, computer-based teaching also had small and positive effects on attitudes of college students toward instruction. College students tended to like their courses somewhat more when instruction was computer-based. Finally, computer-based teaching had a positive effect on student attitudes toward the computer.

Although CBE produced only modest effects in the typical evaluation study, some individual studies reported large effects. Included among the studies that reported unusually strong, positive effects are several in education and psychology: Cartwright, Cartwright, and Robine (1972); Green and Mink (1973); Lorber (1970); and Roll and Pasen (1977). Other studies that reported strong positive effects come from the area of music education: Humphries (1980) and Vaughn (1977). researchers may wish to scrutinize results of these atypical studies very carefully. The CBE programs evaluated in these studies may point the way to better uses of CBE in the years ahead.

References

Aird, C. L. (1974). An investigation of self-study computer based instruction in engineering. Dissertation Abstracts International, 34, 4906A.

Alderman. D. L. (1978). Evaluation of the TICCIT computer-assisted instructional system in the community college (ETS PR 78-10). Princeton, NJ: Educational Testing Service.

Alderman, D. L., Appel, L. R., & Murphy, R. T. (1978). PLATO and TICCIT: An evaluation of CAI in the community college. Educational Technology, 18, 40-45.

Allen, M. W. (1972). The prediction of achievement in computer assisted instruction versus lecture instruction using linear multiple regression techniques. Dissertation Abstracts International, 32, 6612B.

Anandam, K., Eisel, E., & Kotler, L. (1980). Effectiveness of a computer-based feedback system for writing. Journal of Computer-Based Instruction, 6, 125-133.

Anderson, T. H., Anderson, R. C., Dalgaard, B. R., Paden, D. W., Biddle, W. B., Surber, J. R., & Alessi, S. M. (1975). An experimental evaluation of a computer based study management system. Educational Psychologist, 11, 184-190.

Andrews, C. S. (1974). An investigation of the use of computer-assisted instruction in French as an adjunct to classroom instruction. Dissertation Abstracts International, 34, 5900A.

Arnett, S. J. (1976). Comparison of computer assisted instruction versus conventional instruction in a beginning accounting course. Dissertation Abstracts International, 37, 3719A.

Arsenty, R. P., & Kieffer, G. H. (1971). An evaluation of the teaching effectiveness of PLATO in a first level biology course. Urbana, IL: University of Illinois. (ERIC Document Reproduction Service No. ED 128 171)

Axeen, M. E. (1967). Teaching library use to undergraduates: Comparison of computer-based instruction and the conventional lecture. Urbana: University of Illinois. (ERIC Document Reproduction Service No. ED 014 316)

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (1984, August). The influence of study features on outcomes of educational research. Paper presented at the meeting of the American Psychological Association, Toronto.

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (1985). Effectiveness of computer-based education in secondary schools. Ann Arbor: University of Michigan, Center for Research on Learning and Teaching.

Barrozo, T., Richards, H., & Olsen, H. (1978). Impact of CAI for remediating basic skill deficiencies of open admission students. In X. X. XXXXX (Ed.), Proceedings of the 16th Annual Convention of the Association for Educational Data Systems (pp. 91-96). XXCity, XX: XXPublisher.

Baxter, C. A. (1975). The effects of computer-augmented instruction on achievement in the collegiate principles of accounting course. Dissertation Abstracts International, 35, 4752A.

Bell, F. H. (1970). A study of the effectiveness of a computer-oriented approach to calculus. Dissertation Abstracts International, 31, 1096A. (University Microfilms No. 70-14,372)

Bickerstaff, D. D., Jr. (1977). The effect of computer assisted instruction drill and practice used to obtain homework credit on achievement and attitudes of college level intermediate algebra students. Dissertation Abstracts International, 37, 5659A.

Bitter, G. G. (1971). Effect of computer applications on achievement in a college introductory calculus course. Dissertation Abstracts International, 31, 6109B.

Boen, L. L. (1983). Traditional and computer directed instruction (CDI) of study skills in college students. Dissertation Abstracts International, 43, 3213A.

Boysen, J. P., & Francis, P. R. (1982). An evaluation of the instructional effectiveness of a computer lesson in biomechanics. Research Quarterly for Exercise and Sport, 53, 232-235.

Broh, C. A. (1975, September). Achievement and attitude with computer related instruction: A field experiment. Paper presented at the meeting of the American Political Science Association, San Francisco. (ERIC Document Reproduction Service No. ED 110 399)

Byers, C. R. (1974). An experimental comparison of three modes of computer-supported instruction. Dissertation Abstracts International, 34, 6938A. (University Microfilms No. 74-10,489)

Cartwright, C. A., Cartwright, G. P., & Robine, G. C. (1972). CAI course in the early identification of handicapped children. Exceptional Children, XX, 453-459.

Caruso, D. E. F. (1970). An experiment to determine the effectiveness of an interactive tutorial program, implemented on the time sharing IBM system 360, model 50, in teaching a subject-oriented user to formulate inquiry statements to a computerized on-line information retrieval system. Dissertation Abstracts International, 30, 3484A. (University Microfilms No. 70-2051)

Castleberry, S. J., Culp, G. H., & Lagowski, J. J. (1973). The impact of computer-based instructional methods in general chemistry. Journal of Chemical Education, 50, 469-472.

Castleberry, S., & Lagowski, J. J. (1970). Individualized instruction using computer techniques. Journal of Chemical Education, 47, 91-96.

Castleberry, S. J., Montague, E. J., & Lagowski, J. J. (1970). Computer-based teaching techniques in general chemistry. Journal of Research in Science Teaching, 7, 197-208.

Clark, R. E. (in press). Confounding in educational computing research. Journal of Educational Computing Research.

Cohen, J. (1977). Statistical power analysis for the behavioral sciences (Rev.ed.). New York: Academic Press.

Cokewood, D. B. (1980). A comparison of the effectiveness of computer assisted instruction and programmed instruction in improving problem-solving in college level basic electronics. Dissertation Abstracts International, 41, 1445A.

Coombs, F. S. (1976). Playing politics: Reflections on an experiment in computer-based education. In J. Pool (Ed.), Computer assisted instruction in political science. Washington, DC: American Political Science Association.

Cox, S. R. (1974). Computer-assisted instruction and student performance in macroeconomic principles. The Journal of Economic Education, 6, 29-37.

Crawford, A. M., and others. (1978). Evaluation of a computer-based course management system. Final report. XXXXX, IL: Illinois University. (ERIC Document Reproduction Service No. 165 790)

Culp, G. H., & Lagowski, J. J. (1971). Studies involving the application of computer techniques to undergraduate organic chemistry instruction. Journal of Research in Science Teaching, 8, 357-362.

Culp, G. H., Stotter, P. L., & Gilbert, J. C. (1973). Adapting computer-based instruction to undergraduate organic chemistry: An experimental course. Austin: University of Texas. (ERIC Document Reproduction Service No. ED 116 605)

Cunningham, S. L., & Fuller, R. G. (1973). Evaluation of an experiment in computer-assisted tutoring. The Physics Teacher, 11, 238-239.

Daellenbach, L. A., and others. (1977). Studies in economic education: No. 4. An evaluation of the cognitive and affective performance of an integrated set of CAI materials in the principles of macroeconomics. La Crosse: Wisconsin University, Center for Economic Education. (ERIC Document Reproduction Service No. 150 057)

Daughdrill, R. W. (1978). A comparative study of the effectiveness of computer-assisted instruction in college algebra. Dissertation Abstracts International, 39, 3431A.

DeBoer, D. D. (1974). A comparative study of the effects of a computer-oriented approach to introductory calculus. Dissertation Abstracts International, 34, 3912B-3913B. (University Microfilms No. 74-4619)

Deloatch, S. J. (1978). A comparative study of use of computer programming activities in an introductory college mathematics course for disadvantaged students. Dissertation Abstracts International, 38, 6585A. (University Microfilms No. 78-5629)

Diedrick, W., & Thomas, R. (1977). A computer simulation for teaching diagnosis of secondary ignition problems. Journal of Industrial Teacher Education, 14, 44-53.

Diem, D. C. (1982). The effectiveness of computer assisted instruction in college algebra. Dissertation Abstracts International, 43, 1456A.

DuBoulay, J. B., & Howe, J. A. (1982). Logo building blocks: Student teachers using computer-based mathematics apparatus. Computers and Education, 6, 93-98.

Dudley, D. A., Elledge, B., & Mukherjee, T. (1974). The effectiveness of computer-assisted instruction in economics: Some additional evidence. Unpublished manuscript, Appalachian State University.

Durgin, M. W. (1979). The effects of teaching beginning college mathematics with a business emphasis by computer aided instruction. Dissertation Abstracts International, 39, 5380A.

Ellinger, R. S., & Frankland, P. (1976). Computer assisted and lecture instruction: A comparative experiment. Journal of Geography, 75, 109-120.

Emery, E. D., & Enger, T. P. (1972). Computer gaming and learning in an introductory economics course. The Journal of Economic Education, 3, 77-85.

Fiedler, L. A. (1969). A comparison of achievement resulting from learning mathematical concepts by computer programming versus class assignment approach. Dissertation Abstracts International, 29, 3910A. (University Microfilms No. 69-8595)

Friesen, V. E. (1977). The relationship of affective and cognitive variables to achievement and attitude under lecture-discussion and computer-assisted instruction. Dissertation Abstracts International, 37, 4095A.

Gallagher, P. D. (1971). An investigation of instructional treatments and learner characteristics in a computer-managed instruction course (Doctoral dissertation, Florida State University, 1970) Dissertation Abstracts International, 31(9-A), 4543. (University Microfilms No. 71-7013)

Glass, G. V., McGaw, B., & Smith, M. L. (1981). Meta-analysis in social research. Beverly Hills, CA: Sage Publications.

Goodson, C. E. M. (1975). A study of the effectiveness of computer assisted instruction as compared to traditional instruction when utilized in technical mathematics for college students in business and engineering technology. Dissertation Abstracts International, 36, 2688A.

Grandey, R. C. (1971). An investigation of the use of computer-aided-instruction in teaching students how to solve selected multistep general chemistry problems. Dissertation Abstracts International, 31, 6430A. (University Microfilms No. 71-14,764)

Grandey, R. C. (1971). The use of computers to aid instruction in beginning chemistry. Journal of Chemical Education, 48, 791-794.

Gray, C. F. (1973). Expressed student attitude toward conventional versus computer supplemented instruction. Decision Sciences, 4, 141-148.

Green, C., & Mink, W. (1973). Evaluation of computer simulation of experiments in teaching scientific methodology. St. Paul, MN: Macalester College. (ERIC Document Reproduction Service No. 082 475)

Hamm, R. B. (1976). Effects of CAI in a microcounseling model for training facilitative use of verbal communication skills. Dissertation Abstracts International, 36, 7209A. (University Microfilms No. 76-11,948)

Henry, M., & Ramsett, D. (1978). The effects of computer-aided-instruction on learning and attitudes in economic principles courses. The Journal of Economic Education, 10, 26-34.

Herbert, M. L. W. (1981). Computer-assisted instruction versus lecture-exercise instruction in punctuation usage for collegiate business students. Dissertation Abstracts International, 42, 1450A.

Hofstetter, F. T. (1975). GUIDO: An interactive computer-based system for improvement of instruction and research in ear-training. Journal of Computer-Based Instruction, 1, 100-106.

Hollen, T. T., Bunderson, C. V., & Durham, J. L. (1971). Computer based simulation of laboratory problems in qualitative analysis. Science Education, 55, 131-136.

Holoien, M. O. (1971). Calculus and computing: A comparative study of the effectiveness of computer programming as an aid in learning selected concepts in first-year calculus. Dissertation Abstracts International, 31, 4490A.

Homeyer, F. C. (1970). Development and evaluation of an automated assembly language teacher. Austin: University of Texas at Austin. (ERIC Document Reproduction Service No. ED 053 531)

Hong, S. T. (1973). An empirical study of the effectiveness of programed instruction and computer-assisted instruction in elementary accounting. Dissertation Abstracts International, 33, 4589A.

Hsiao, J. C. (1973). The independence of teaching technique and student-ratings of the instructor. Unpublished manuscript, Southern Connecticut State College.

Hughes, R. J. (1977). An experimental study in teaching mathematical concepts utilizing computer-assisted instruction in business machines. Dissertation Abstracts International, 37, 6911A.

Humphries, J. A. (1980). The effects of computer-assisted aural drill time on achievement in musical interval identification. Journal of Computer-Based Instruction, 6, 91-98.

Ibrahim, A. T. (1970). A computer-assisted instruction program for teaching the concepts of limits in freshman calculus (a comparative study). Dissertation Abstracts International, 31, 1689A. (University Microfilms No. 70-20,036)

Jamison, D., Suppes, P., & Wells, S. (1974). The effectiveness of alternative instructional media: A survey. Review of Educational Research, 44, 1-61.

Johnson, F. M. (1970). An experiment in the teaching of programming language/one using computer assisted instruction. Dissertation Abstracts International, 31, 166B.

Johnson, C. W., & Plake, B. S. (1981, April). Interactive study lessons to complement ANOVA. Paper presented at the meeting of the American Educational Research Association, Los Angeles. (ERIC Document Reproduction Service No. 204 361)

Jones, L. A., & Sorlie, W. E. (1976). Increasing medical student performance with an interactive, computer-assisted appraisal system. Journal of Computer-Based Instruction, 2, 57-62.

Karon, L. G. (1976). An experimental study comparing computer-assisted instruction with the traditional lecture method in an introductory learning disabilities course given to medical students. Dissertation Abstracts International, 36, 4226A.

Kelley, A. C. (1972). TIPS and technical change in classroom instruction. American Economic Review, 62, 422-428.

Kockler, L. H. (1973). Using computer assisted instruction in overcoming attitude barriers. Dissertation Abstracts International, 33, 5519A.

Kromhout, O. M., Edwards, S., & Schwarz, G. (1969). A computer-guided, general-education physics course. American Journal of Physics, 37(10), 995-1001.

Kulik, C.-L. C., Kulik, J. A., & Bangert-Drowns, R. L. (1984). Effects of computer-based education on elementary school pupils. Ann Arbor, MI: University of Michigan. (ERIC Document Reproduction Service No. ED 224 016)

Kulik, C.-L. C., Kulik, J. A., & Cohen, P. A. (1980). Technology and college teaching. Teaching of Psychology, 7, 199-205.

Kulik, J. A. (1984, April). Uses and misuses of meta-analysis. Invited address presented at the annual meeting of the American Educational Research Association, New Orleans. (ERIC Document Reproduction Service No. ED 247 270)

Kulik, J. A., Kulik, C.-L. C., & Bangert-Drowns, R. L. (in press). The importance of outcome studies: A reply to Clark. Journal of Educational Computing Research.

Kulik, J. A., Kulik, C.-L. C., & Cohen, P. A. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. Review of Educational Research, 50, 525-544.

Lang, M. T. (1974). Computer extended instruction in introductory calculus. Dissertation Abstracts International, 34, 5662A.

Larson, D. E. (1982). The use of computer-assisted instruction to teach calculation and regulation of intravenous flow rates to baccalaureate nursing students. Dissertation Abstracts International, 42, 3459A.

Lawler, R. M. (1971). An investigation of selected instructional strategies in an undergraduate computer-managed instruction course. Tallahassee: Florida

State University. (ERIC Document Reproduction Service No. ED 054 652)

LeCuyer, E. J., Jr. (1977, June). Teaching a survey of mathematics for college students using a programming language. Paper presented at the Conference on Computers in the Undergraduate Curricula, East Lansing, MI.

Lee, A. L. (1973). A comparison of computer-assisted instruction and traditional laboratory instruction in an undergraduate geology course. Dissertation Abstracts International, 34, 2273A. (University Microfilms No. 73-26,036)

Liu, H.-C. (1975). Computer-assisted instruction in teaching college physics. Dissertation Abstracts International, 36, 1411A. (University Microfilms No. 75-18,862)

Lorber, M. A. (1970). The effectiveness of computer assisted instruction in the teaching of tests and measurements to prospective teachers. Dissertation Abstracts International, 31, 2775A. (University Microfilms No. 70-24,434)

Mancuso, L. C. (1975). The effects of using a lecture-computer simulation teaching methodology in broadcast economics. 1975 Conference on Computers in the Undergraduate Curricula, 6, 163-170.

McAdams, J. K. (1978). A study of the effectiveness of FRTDAP, a computer-aided instruction drill-and-practice system, used in conjunction with video-tapes in teaching FORTRAN. Dissertation Abstracts International, 38, 4347B.

Meyer, J. H., & Beaton, G. R. (1974). An evaluation of computer-assisted teaching in physiology. Journal of Medical Education, 49, 295-297.

Mitzel, H. E. (1967). The development and presentation of four college courses by computer teleprocessing (Report No. BR-5-1194). University Park: Pennsylvania State University, College of Education, Computer-Assisted Instruction Laboratory. (ERIC Document Reproduction Service No. ED 016 377).

Montanelli, R. G. (1979). Evaluating PLATO in the teaching of computer science. Journal of Computer-Based Instruction, 5, 72-76.

Morrison, H. W., & Adams, E. N. (1968). Pilot study of a CAI laboratory in German. Modern Language Journal, 52, 279-287.

Murphy, R. T., & Appel, L. R. (1977). Evaluation of the PLATO IV computer-based education system in the community college (ETS PR 77-10). Princeton, NJ: Educational Testing Service.

Oates, W. R. (1983). Effects of computer-assisted instruction in writing skills on journalism students in beginning newswriting classes. Dissertation Abstracts International, 43, 2822A.

Ozarowski, P. C., Jr. (1974). A study in the design and implementation of a course in the basic fundamentals of statistics via a computer (Doctoral dissertation, University of Alabama, 1973). Dissertation Abstracts International, 34(5-A), 2310. (University Microfilms No. 73-27 317)

Paden, D. W., Dalgaard, B. R., & Barr, M. D. (1977). A decade of computer-assisted-instruction. The Journal of Economic Education, 9, 14-20.

Proctor, W. L. (1969). A comparison of two instructional strategies based on computer-assisted instruction with a lecture-discussion strategy for presentation of general curriculum concepts. Dissertation Abstracts International, 29, 2075A. (University Microfilms No. 69-591)

Rice, B. A. P. (1974). A comparison of computer-assisted instruction (CAI), programmed-instruction, and lecture in teaching fundamental concepts of calculus. Dissertation Abstracts International, 34, 3927B.

Roe, M. H., & Aiken, R. M. (1976). A CAI simulation program for teaching IRI techniques. Journal of Computer-Based Instruction, 2, 52-56.

Roll, J. H., & Pasen, R. M. (1977). Computer-managed instruction produces better learning in an introductory psychology course. 1977 Conference on Computers in the Undergraduate Curricula, 8, 229-237.

Romaniuk, E. W. (1978). A summative evaluation of the CAI course 'COMPS.' Edmonton: University of Alberta. (ERIC Document Reproduction Service No. ED 153 604)

Rota, D. R. (1982). Computer-assisted instruction, lecture instruction, and combined computer-assisted/lecture instruction: A comparative experiment. Dissertation Abstracts International, 42, 4809A.

Rushinek, A., Rushinek, S., & Stutz, J. (1981). The effects of computer assisted instruction upon computer facility and instructor ratings. Journal of Computer-Based Instruction, 8, 43-46.

Saul, W. E. (1975). An experimental study of the effect of computer augmented instruction on achievement and attrition in beginning accounting at Miami-Dade Community College, North Campus. Dissertation Abstracts International, 35, 4757A.

Skavaril, R. V. (1974). Computer-based instruction of introductory statistics. Journal of Computer-Based Instruction, 1, 32-40.

Skavaril, R. V., Birky, C. W., Jr., Duhrkopf, R. E., & Knight, J. A. (1976). The use of CAI to provide problems for students in introductory genetics. Journal of Computer-Based Instruction, 3, 13-20.

Smith, R. B. (1976). The effects of computer assisted feedback on students' performance in a televised college course. Dissertation Abstracts International, 36, 5163A. (University Microfilms No. 76-2516)

Steinkamp, S. W. (1977). A computer-implemented modeling and problem-solving approach to teaching statistics. In X. X. XXXXX (Ed.), New Directions in Educational Computing: Proceedings of the 1977 Winter Conference ADCIS (pp. XXX-XXX). XXCity, XX: XXPublisher.

Suppes, P., & Morningstar, M. (1969). Computer-assisted instruction. Science, 166, 343-350.

Swigger, K. M. (1976). Automated Flanders interaction analysis. Journal of Computer-Based Instruction, 2, 63-66.

Thompson, F. A. (1977). TIPS teaching information processing systems implementation at Riverside City College, 1976-77: An experiment in educational innovation. Final report. Riverside, CA: Riverside City College. (ERIC Document Reproduction Service No. 142 248)

Tira, D. E. (1977). Rationale for and evaluation of a CAI tutorial in a removable partial prosthodontics classification system. Journal of Computer-Based Instruction, 4, 34-42.

Tollefson, N. (1978). A comparison of computerized and paper-pencil formative evaluation. College Student Journal, 12, 103-106.

Torop, W. (1975). An analysis of individualized learning system chemistry. Paper presented at the meeting of the National Association for Research in Science Teaching, Los Angeles. (ERIC Document Reproduction Service No. ED 110 321)

Tsai, S.-Y. W., & Pohl, N. F. (1977). Student achievement in computer programming: Lecture vs. computer-aided instruction. Journal of Experimental Education, 46, 66-70.

Underkoffler, M. M. (1970). Computer assisted instruction in college general education mathematics. Dissertation Abstracts International, 30, 4700A.

Vaughn, A. C., Jr. (1977). A study of the contrast between computer assisted instruction and the traditional teacher/learner method of instruction in basic musicianship. Dissertation Abstracts International, 38, 3357A. (University Microfilms No. 77-25,414)

Ward, R. G., & Ballew, L. N. (1972). The experimental use of a computer to teach basic set theory. Journal of Educational Data Processing, 9, 1-8.

Weiss, E. (1972). An investigation of the relative effectiveness of two techniques of teaching a transitional course in physics on the college level. Dissertation Abstracts International, 32, 2411A. (University Microfilms No. 71-28,569)

Wolcott, J. M. (1976). The effect of computer-assisted instruction, traditional instruction, and locus-of-control on achievement of beginning typewriting students. Dissertation Abstracts International, 37, 1942A.

Wood, L. J. (1976). Computer assisted test construction in the BYU Library School. Provo, UT: Brigham Young University. (ERIC Document Reproduction Service No. ED 144 602)

Table 1

Categories Used to Describe Study Features

Computer Use

Type of application

Computer-assisted instruction (CAI) -- The computer provides (a) drill-and-practice exercises but not new materials, or (b) tutorial instruction that includes new material.

Computer-managed instruction (CMI) -- The computer evaluates student test performance, guides students to appropriate instructional resources, and keeps records of student progress.

Computer-enriched instruction (CEI) -- The computer (a) serves as a problem-solving tool, (b) generates data at the student's request to illustrate relationships in models of social or physical reality, or (c) executes programs developed by the student.

Duration of instruction

One semester or less

More than one semester

Author of program

Local -- Computer materials were developed locally for a specific setting.

Other -- Computer materials were developed for use in a wide variety of settings.

Type of computer interaction

Off-line

Terminal with mainframe

Microcomputer

Methodology

Subject assignment

Random -- Subjects were randomly assigned to the experimental and control groups.

Nonrandom -- A quasi-experimental design was used.

Control for instructor effects

Same instructor -- The same teacher or teachers taught both the experimental and control groups.

Different instructors -- Different teachers taught the two groups.

Control for historical effect

Same semester -- Subjects in experimental and control groups were taught concurrently.

Different semesters -- Two groups were not taught concurrently.

Control for test-author bias

Commercial -- A standardized test was used as the criterion measure for student achievement.

Local -- A locally developed tests was used as the criterion measure.

Control for bias in test scoring

Objective -- Objective, machine-scorable examinations were used to measure student achievement, e.g., multiple-choice tests.

Nonobjective -- Subjective decisions had to be made in scoring tests, e.g., essay tests.

Control for evaluator involvement

Involved -- The evaluator was involved in developing the CBE material and/or in conducting the CBE program.

Not involved

Field-tested computer materials

Yes

No

Settings

Course emphasis on science

"Hard" Science -- Course emphasizes the hard sciences, engineering, mathematics, or agriculture.

"Soft" discipline -- Emphasis is on the social sciences, humanities, or education.

Course emphasis on pure knowledge

Pure knowledge -- Course does not emphasize practical application of knowledge, e.g., English, chemistry, physiology, and psychology courses.

Applied knowledge -- Emphasis is on practical application, e.g., courses in mechanical engineering, special education, and economics.

Course emphasis on life systems

Life -- Course emphasis is on living or organic objects of study, e.g., courses in physiology, special education, and psychology.

Non-life systems -- Emphasis is on inanimate objects, e.g., courses in chemistry, mechanical engineering, English, and economics.

Subject ability level

Low: Average SAT scores for freshmen entering the institution are below 425 or average ACT is below 20.

Average: Average SAT between 425 and 525, or average ACT between 20 and 23.

High: Average SAT between 525 and 800, or average ACT above 23.

Publication history

Year of the report

Before 1969

1970 - 1974

1975 - 1979

1980 - 1984

Source of study

Technical report -- Clearinghouse document, paper presented at a convention, etc.

Dissertation

Professional journal -- Journal article, scholarly book, etc.

Table 2

Major Features and Achievement Effect Sizes (ES) in 99 Studies of Computer-Based Education

Study	Place	Course content	Use	Duration in weeks	ES
Aird, 1974	University of Virginia	Mechanical engineering	Management	18	0.70
Alderman, 1978	Northern Virginia Community College & Phoenix College	English & math	Tutorial	18	0.15
Allen, 1972	Ohio State University	Psychology	Tutorial	3	0.07
Anandam, Eisel & Kotler, 1980	Community College in Florida	English composition	Management	12	0.40
Anderson, 1975	University of Illinois	Economics	Tutorial	18	0.14
Andrews, 1974	Florida State University	French	D & P	12	0.26
Arnett, 1976	California State College, Dominguez Hills	Accounting	Problem solving	6	0.16
Axeen, 1967	University of Illinois	Library science	Tutorial	9	-0.13
Barrozo, Richards & Olsen, 1978	Medgar Evans College, CUNY	Basic skills	Tutorial	18	0.19
Baxter, 1975	Georgia Southwestern College	Accounting	Problem solving	11	0.03
Bell, 1970	Cornell University	Calculus	Programming	4	0.23
Bickerstaff, 1977	Kansas State University	Math	D & P	3	0.24[a]
Bitter, 1971	University of Denver	Calculus	Programming	18	0.28
Boen, 1983	University of Arkansas	Study skills	Tutorial	1	0.92
Boysen & Francis, 1982	Iowa State University	Biomechanics	D & P	1	0.62
Broh, 1975	State University of New York, Genesco	American government	Problem solving	5	0.21
Byers, 1974	University of Minnesota	Quantitative analysis	Tutorial	12	-0.08

Table 2 (continued)

Study	Place	Course content	Use	Duration in weeks	ES
Cartwright, Cartwright, & Robine, 1972	Pennsylvania State University	Exceptional children	Tutorial	10	2.17
Caruso, 1970	University of Pittsburgh	Library science	Tutorial	1	-0.32
Castleberry, Montague & Lagowski, 1970	University of Texas	General chemistry	Tutorial	18	0.40
Cokewood, 1980	Kean College	Electronics	Simulation	10	0.33
Coombs, 1976	University of Illinois	American government	Simulation	8	0.25
Cox, 1974	Arizona State University	Economics	Simulation	18	0.22
Crawford, Montague, & Smith	University of Illinois	Economics	Management	18	0.02
Culp & Lagowski, 1971	University of Texas	Chemistry	Tutorial	18	0.32
Cunningham & Fuller, 1973	University of Nebraska	Physics	Tutorial	1	0.38
Daellenbach, Schoenberger & Wehrs, 1977	University of Wisconsin, Whitewater	Economics	Tutorial	18	0.04
Daughdrill, 1978	Copiah-Lincoln Junior College	Algebra	Programming	18	0.09
DeBoer, 1974	Vanderbilt University	Calculus	Programming	18	0.03
Deloatch, 1978	Indiana University	Compensatory math	Programming	18	0.03
Diem, 1982	Florida Atlantic University	Algebra	Tutorial	2	-1.20
DuBoulay & Howe, 1982	Edinburgh, Scotland	Math	Problem Solving	17	0.10
Durgin, 1979	Black Hills State College	Math	Programming	14	0.02
Ellinger & Frankland, 1976	University of Iowa	Geography	Simulation	1	-0.14
Emery & Enger, 1972	St. Olaf College	Economics	Simulation	1	0.43
Fiedler, 1969	Black Hawk College	Math	Programming	18	0.33
Friesen, 1977	Kansas State University	Math	Tutorial	1	-0.10
Goodson, 1975	University of Houston	Algebra	Tutorial	6	0.04

Table 2 (continued)

Study	Place	Course content	Use	Duration in weeks	ES
Grandey, 1971	University of Illinois	Chemistry	Tutorial	3	0.69
Gray, 1973	Oregon State University	Operations management	Simulation	1	0.25
Green & Mink, 1973	Macalaster College	Psychology	Simulation	2	1.27
Hamm, 1976	East Texas State University	Counselor education	Tutorial	6	0.08
Henry & Ramsett, 1978	University of North Dakota	Economics	Management	18	0.34
Herbert, 1981	University of Wisconsin, Whitewater	Punctuation usage	Tutorial	1	0.35
Hofstetter, 1975	University of Delaware	Ear Training in Music	D & P	7	0.69
Hollen, Bunderson, & Dunham, 1971	University of Texas	Chemistry	Simulation	1	0.24[a]
Holoien, 1970	Moorhead State College	Calculus	Programming	18	0.10
Homeyer, 1970	University of Texas	Computer programming	Tutorial	15	-0.21
Hong, 1973	State Island Community College, CUNY	Accounting	Problem solving	18	0.41
Hughes, 1977	Richland Community College	Business machines	Tutorial	15	0.17
Humphries, 1980	Arizona State University	Music theory	D & P	3	1.94
Ibrahim, 1970	SUNY, Brockport	Calculus	Tutorial	2	0.08
Johnson, 1970	University of North Carolina	Computer programming	D & P	18	-0.22
Johnson & Plake, 1981	University of Nebraska	Advanced statistical methods	Tutorial	18	0.86
Jones & Sorlie, 1976	University of Illinois	Basic science in medical school	Tutorial	36	0.48

Table 2 (continued)

Study	Place	Course content	Use	Duration in weeks	ES
Karon, 1976	Northwestern University	Learning disabilities	Tutorial	6	0.19
Kelley, 1972	University of Wisconsin	Economics	Management	8	0.29
Kockler, 1973	Iowa State University	Math	D & P	6	0.18
Lang, 1974	University of Texas	Calculus	Problem solving	7	0.24
Larson, 1982	Grand Valley State College	Nursing	Simulation	1	0.15
Lawler, 1971	Florida State College	Health education	Management	10	-0.11
LeCuyer, 1977	University of Massachusetts	Introductory math	Programming	18	0.24[a]
Lee, 1973	University of Texas	Introductory geology	Tutorial	18	-0.22
Liu, 1975	Western Michigan University	General physics	Tutorial	6	0.64
Lorber, 1970	University of Athens	Instructional process & curriculum	Tutorial	5	1.33
Mancuso, 1975	University of Southern Mississippi	Broadcast economics	Simulation	18	-0.01
McAdams, 1978	University of Missouri, Rolla	Programming	D & P	13	-0.55
Meyer & Beaton, 1974	South Africa	Physics	Tutorial	1	-0.02
Mitzel, 1967	Pennsylvania State University	Engineering	Tutorial	6	0.28
Mitzel, 1967	Pennsylvania State University	Speech pathology & audiology	Tutorial	5	-0.82
Montanelli, 1979	University of Illinois	Computer programming	Tutorial	18	0.24[a]
Morrison & Adams, 1968	SUNY, Stony Brook	German	Tutorial	18	-0.26

Table 2 (continued)

Study	Place	Course content	Use	Duration in weeks	ES
Murphy & Appel, 1978	Community College in Illinois	Chemistry, biology, math & English	Tutorial	12	-0.01
Oates, 1983	Indiana University	Language arts	Tutorial	18	0.46
Paden, Dalgaard & Barr, 1977	University of Illinois	Economics	Tutorial	6	-0.04
Proctor, 1969	Florida State University	Education	Tutorial	2	0.44
Rice, 1974	Georgia State University	Calculus	Tutorial	3	0.24[a]
Roe & Aiken, 1976	University of Tennessee	Education	Simulation	2	0.67
Roll & Pasen, 1977	Harper College	Psychology	Management	18	1.46
Romaniuk, 1978	Northern Alberta Institute of Technology, Canada	Computer programming	Tutorial	2	0.06
Rota, 1982	Robert Morris College	Data processing	Tutorial	6	-0.16
Saul, 1975	Miami-Dade Community College	Accounting	Problem solving	18	0.04
Skavaril, 1974	Ohio State University	Statistics	Tutorial	11	0.16
Skavaril, Birky, Duhrkopt, & Knight, 1976	Ohio State University	Genetics	Tutorial	12	0.20
Smith, 1976	Orange Coast Community College	Psychology	Management	15	-0.02
Steinkamp, 1977	University of Illinois	Statistics	Simulation	18	0.22
Suppes & Morningstar, 1969	Stanford University	Russian	Tutorial	36	0.71
Swigger, 1976	University of Iowa	Methods of instruction	Tutorial	2	0.78
Thompson, 1977	Riverside City College	Economics	Management	18	0.22
Tira, 1977	University of Missouri, Kansas City	Dental Classification	Tutorial	1	1.25

Table 2 (continued)

Study	Place	Course content	Use	Duration in weeks	ES
Tollefson, 1978	University of Kansas	Educational Measurement	Management	14	0.52
Torop, 1975	West Chester State College	Chemistry	Tutorial	18	-0.25
Tsai & Ponl, 1977	University of Santa Clara	Computer programming	Tutorial	15	0.47
Underkoffler, 1970	Winona State College	Math	Management	9	0.33
Vaughn, 1977	Oregon State University	Music	Tutorial	8	1.84
Ward & Ballew, 1972	East Texas State University	Set theory	Tutorial	2	-0.86
Weiss, 1971	New York University	Physics	Management	14	0.23
Wolcott, 1976	Ocean County College	Typewriting	Tutorial	15	-0.34
Wood, 1976	Brigham Young University	Cataloging	Management	18	0.20

[a]This study yielded a positive effect that was not statistically significant. The report did not include enough detail, however, for direct calculation of ES. The ES reported here and used in the analysis is an estimated value; it is the median ES in all studies of CBE that reported a statistically significant ES.

Table 3

Means and Standard Errors of Effect Sizes (ES) for 99 CBE Studies Classified by Study Features

Categories	N	ES M	ES SE
Use of computer			
CAI	58	.26	.08
CMI	13	.35	.11
CEI	28	.23	.05
Duration of Instruction			
1-4 weeks	27	.32	.12
5-8 weeks	17	.32	.14
9-12 weeks	12	.30	.17
13-16 weeks	9	.03	.12
17 or more	34	.24	.06
Author of program			
Local	83	.26	.06
Other	16	.28	.11
Type of interaction			
Off-line	21	.18	.03
Terminal with main frame	73	.27	.06
Microcomputer	5	.43	.47
Subject assignment			
Random	39	.31	.11
Nonrandom	60	.23	.04

Table 3 (continued)

Categories	N	ES M	ES SE
Instructors			
Same	68	.23	.10
Different	31	.32	.06
Semesters			
Same	95	.26	.05
Different	4	.26	.21
Test author bias			
Commercial test	14	.26	.05
Local test	85	.26	.16
Test scoring bias			
Objective	83	.26	.06
Non objective	16	.29	.09
Evaluator involvement			
Involved	88	.27	.06
Not involved	11	.20	.09
Field tested material			
Yes	37	.31	.06
No	62	.23	.10
Content emphasis on "Hard" discipline*			
Hard	44	.15	.06
Soft	55	.35	.08

Table 3 (continued)

Categories	N	ES M	ES SE
Content emphasis on "Pure" knowledge			
Pure	58	.26	.07
Applied	41	.26	.08
Content emphasis on "Life" studies**			
Life	22	.54	.14
Nonlife	77	.18	.05
Ability of subjects			
Low	29	.17	.10
Average/mixed	43	.30	.08
High	27	.29	.08
Nature of publication*			
Unpublished	12	.11	.14
Dissertation	46	.16	.07
Published	41	.42	.08
Year of publication			
1965-1969	7	.08	.20
1970-1974	35	.27	.09
1975-1979	45	.25	.06
1980-1984	12	.40	.21

Table 4

Effects in Other Outcome Areas

			Effect size (ES)			
Study	Instructional time (Ratio of X:C)	Course completion (h)	Retention at follow-up	Attitude toward computer	Attitude toward instruction	Attitude toward subject
Aird, 1974		-.05				
Alderman, 1978		-.68			-.36	
Anandam, Eisel & Kotter, 1980					.18	.13
Anderson, 1975		-.14			.57	
Axeen, 1967	.69				.37	
Baxter, 1975	.85	-.04				
Bell, 1970				-.01		
Bickerstaff, 1977				.22		.23
Bitter, 1971		00				
Boen, 1983	.53			-.12		
Broch, 1975				-.18		-.31
Byers, 1974		00		.64		
Cartwright & Robine, 1972	67					
Castleberry et al., 1973		- 08				
Cokewood, 1980		- 09	.06			
Culp & Lagowski, 1971					.72	
Culp, Statter & Gilbert, 1973		.08				
Daellenbach et al., 1977						.09
Daughdrill, 1978		-.12				
Deboer, 1974						-.26

Table 4 (continued)

Study	Instructional time (ratio of X:C)	Course completion (h)	Effect size (ES) Retention at follow-up	Attitude toward computer	Attitude toward instruction	Attitude toward subject
Deloatch, 1978						.61
Diem, 1982		-.46				
Durgin, 1979	97				-.25	-.37
Fiedler, 1969		.04				
Friesen, 1977				1.05		-.29
Grary, 1973				.54		
Green & Mink, 1973					-.26	-.34
Hollen et al., 1971	.48					
Holoien, 1970						-.08
Homeyer, 1970	.57			.06		
Hong, 1978		-.30				
Hughes, 1977						-.10
Ibrahim, 1970			.10			.24
Kavaril, 1974	.70					
Kelley, 1972					.00	
Kockler, 1973				.99		-.05
Larson, 1982	.82		.08			
Lawler, 1971						.09
Lee, 1973	.50	-.17				
Locker, 1970	64					
Meyer & Beaton, 1974			.18			
Montanelli, 1979		-.32				

Table 4 (continued)

			Effect size (ES)			
Study	Instructional time (Ratio of X:C)	Course completion (h)	Retention at follow-up	Attitude toward computer	Attitude toward instruction	Attitude toward subject
Morrison & Adams, 1968						
Murphy & Appel, 1978		.07		.19		-.02
Proctor, 1969	.68		.53		.49	
Roll & Pasen, 1977					.96	
Romaniuk, 1978	.80					
Roter, 1982				-.46		
Saul, 1975		-.02				
Smith, 1976		.22			.07	
Steinkamp, 1977					1.03	
Suppes & Morningstar, 1969		.72				
Thompson, 1977		.04				
Tollefson, 1978					.51	
Ward & Ballew, 1972	38		.10			
Wolcott, 1976	.64					