The Effects of Computer-Assisted Instruction on Jordanian College Students' Achievements in an Introductory Computer Science Course

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Abstract

The purpose of this study was to investigate the effects of traditional instruction (TI) plus Computer-Assisted Instruction (CAI) versus TI alone on college students' achievements in an introductory computer science course. This study was conducted at a small government university in Jordan using a Quasi-experimental, nonequivalent control group design. A courseware was developed to investigate the difference between two groups who were given a pretest and a posttest to measure achievement of the course objectives. An analysis of covariance on the posttest scores with pretest scores as the covariate showed that the TI plus Computer Assisted Instruction group performed significantly better than the TI alone group with a small effect size. It was concluded that TI plus CAI format should be considered as a substitute to the TI alone format.

INTRODUCTION

In recent years, rapid advances in information technology strongly increased the interest of Jordan's Ministries of Education and Higher Education in the use of technology for instructional purposes. The two ministries realized that traditional methods of instruction were not preparing students with a competitive educational foundation to endure the pressures of a technologically reliant society. According to the United States Agency for International Development (2004):

> In July 2003, the GOJ launched the Education Reform for the Knowledge Economy (ERfKE) initiative. This five-year, $380 million program, developed with USAID assistance, is one of the most ambitious education reform programs in the Middle East and North Africa region to date. The goal of Jordan's education reform program is to re-orient education policy, restructure education programs and practices, improve physical learning environments, and promote learning readiness through improved and more accessible early childhood education.

However, the Jordanians' research on the effects of teaching and learning with technology on students' achievements is limited in the information it provides to guide researchers, educators, and legislators in Jordan in establishing environments that will promote learning for students. Particularly, there was no known study attempting to investigate the effectiveness of CAI with college students enrolled in an introductory computer science course. This introductory course in computer science provided a general introduction to the information technology concepts, computer hardware and software, networks, and internet. It was taught in a traditional format where much of the learning comes from reading the textbooks, attending instructor-led classes, and computer lab assignments. However, in recent years, computers and communications technology have drastically transformed the delivery medium of instruction. For example, the development of CAI is one of the most rapidly advancing and interesting medium of instruction in recent years. Therefore, it is worthwhile to explore the effects of CAI on Jordanian college students' achievements.

LITERATURE REVIEW

According to Reiser and Dempsey (2002) in 1950s researchers at IBM developed the first CAI author language and designed CAI programs for public schools. In 1960s Richard Atkinson and Patrick Suppes worked on the applications of CAI for public schools and universities. Pagliaro (1983) indicated that CAI impact of the 1970s on education is very limited. The Center for Social Organization of Schools (1983) reported that by January 1983, more than 40% of elementary schools and 75% of secondary schools used computers for instructional purposes in the United States of American. Since 1995, rapid advances in information technology strongly increased the interest in the use of technology for instructional purposes.

Theorists of instruction (e.g., Bruner, 1966; Merrill, 1971; Briggs, 1977; Gagne, 1979) have proposed theoretical models of the connections between the learner's environment and the internal events of cognition and learning. To promote learning, these theorists prescribed the applications of various instructional strategies, such as the selection of the appropriate delivery medium of instruction. Through the extraordinary storage and delivery capabilities of computers and advancements in software and communications technologies today, it is possible to present learning information in new meaningful ways, engage various senses, record and assess learner's choices and performance, and suggest remedial feedback based on the learner's performance. Learners who are using CAI as a medium of instruction, can control the sequence of instructional materials, seeing, hearing, reading, and actively manipulating materials at their own pace.

Throughout the past two decades, a large number of researchers in various fields (e.g., personnel psychology, English, nursing, math, physical education, science, information technology) from around the world have become increasingly interested in the effectiveness of technology on students outcomes (e.g., Brown, 2001; Chen, 2005; Chang, 2002; Jantz, Anderson, & Gould, 2002; Matheson, 1990; McKethan, Everhart, & Stubblefield, 2000; Yildirim, Ozden, & Aksu, 2001). As a result, many meta-analyses studies have been conducted to review and synthesize the outcomes of these studies.

For example, Waxman, Connell, and Gray (2002) reviewed and synthesized research on the effects of teaching and learning with technology on students' cognitive, affective, and behavioral outcomes of learning. Statistical data from 20 studies that contained a combined sample of approximately 4,400 students was used to compute the effect sizes and found that the average effect size across all outcomes was .30. The results indicated that the effect on student outcomes when compared to TI was small.

Another study by Blok, Oostdam, Otter, and Overmaat (2002) who examined the effectiveness of CAI programs in supporting beginning readers and found that the corrected overall effect size estimate was .19 which was based on 42 studies reviewed. Their findings indicated that the effects of CAI programs have positive but small effects, which are consistent with Ouyang (1993) findings.

In a similar study, 254 controlled evaluation studies that compared student learning in classes taught with and without computer-based instruction (CBI) were examined (Kulik & Kulik, 1991). Results indicated that CBI usually produced positive effects on students' performance. Yaakub and Finch (2001) compared the effectiveness of CAI with TI and found that the evaluation of 21 studies yielded 28 effect sizes with an overall positive effect size of 0.35 for CAI-based technical education instruction. Burns and Bozeman (1981) examined 40 studies that compared the effectiveness of TI alone with a combination of TI and CAI on students' mathematics achievement. The results indicated that the combined traditional CAI approach was significantly more effective.

At the college level, Christmann and Badgett (2000) examined 18 studies for the effectiveness of CAI and found an overall mean effect size of 0.127. The results indicated that students who received TI supplemented with CAI performed slightly better than those who

received only TI. Furthermore, this study found that CAI was most effective in aviation and English and least effective in mathematics and music. In a similar study, 42 studies that involved college students were examined for the effect of CAI on students achievement in science education when compared to TI and found a small effect of .27 (Bayraktar, 2001-2002).

Overall, most of the CAI research studies reported small positive effect of CAI on the achievement of students at different educational levels. The purpose of this study was to address the following research question using a quasi-experimental design: Is there a significant difference in achievement scores between college students who receive TI plus CAI and those who receive only TI in an introductory computer science course? Based on this research review, it is anticipated in this study that students who receive TI plus CAI would perform better than those who receive only TI.

METHOD

Design

This study utilized a quasi-experimental, nonequivalent control group design that is a suitable alternative to an experimental design when randomization is not possible (Cook & Campbell, 1979; Gall, Borg, & Gall, 1996; Huck, Cormier, & Bounds, 1974). The nonequivalent control group design can be utilized as a nonequivalent comparison group design in which two treatments are applied (Huck et al., 1974). Since the subjects in this type of design were not randomly assigned, intact classes of students were randomly assigned to either the experimental group or the control group where both intact groups took a pretest and a posttest.

Although comparison groups are considered nonequivalent groups, a logical basis for comparison of the two groups in this study exist. Mainly, the university admission policy for all new undergraduate students required a high school grade-point average (GPA) of at least 65 with highest possible score of 100. Secondly, the obtained high school mean grade-point-averages for the control and experimental groups were 76 and 74 (with highest possible score of 100), respectively. Therefore, both groups in this study appeared to have comparable academic performance with a small difference in favor of the control group. In the following paragraph a description of the educational courseware development, participants, instrument, procedures, and statistical analysis is presented.

Educational Courseware Development

According to Alessi & Trollip (2001) a designer of instructional interactive multimedia should base the development of materials on the behavioral, cognitive, and constructivist approaches. These approaches should be based on principles that include reinforcement, attention, perception, encoding, memory, comprehension, active learning, motivation, locus of control, mental models, metacognition, transfer of learning, individual differences, knowledge construction, situated learning, and collaborative learning. In addition, the designer should account for the logistic considerations such as cost, dissemination, and ease of revision also influence design (Alessi & Trollip, 2001).

To develop the educational courseware entitled "Information Technology for Beginners" (ITB) Version.1, the researcher designated a team of three computer programmers, one instructional designer, four instructors as subject matter experts, and one Arabic language specialist. The ITB language of instructions was in Arabic. The design of the educational courseware was based on Smith and Ragan's (2005) Instructional Design Process Model (Analysis, Strategy, and Evaluation) and Alessi et al. (2001) Model for Design and Development (Planning, Design, and Development).

ITB was mainly developed using Macromedia Authorware 7.0 and was implemented on an IBM personal computer platform. It contained five sections, each of which had lessons, interactive exercises, a summary, and a glossary. The topics of the five sections were (1)

Information Technology Concepts, (2) Hardware, (3) Software, (4) Networks, and (5) Internet. The content of these sections were based on the available textbooks used to teach the course in a traditional method. To promote active learning and address different learning styles, the ITB's multimedia elements included interactive activities and quizzes, audio, video, graphics, text, and animation. The design of the navigational icon options gave users full control where to navigate the courseware (i.e., go to main menu; go to current section menu; go back a page; go forward a page; exist). Additionally, ITB featured two 50 question achievement tests generated randomly and provided immediate feedbacks to the learners regarding their achievement test scores.

During the development of ITB, it was formatively evaluated by an expert review panel and a student review panel. Summative evaluation was also conducted by a pilot study using a quasi-experimental design. This process resulted in minor changes to ITB such as adding more interactive activities and quizzes.

Participants

The sample consisted of college students at the Al Al-Bayt University, Mafraq, Jordan. Random assignment of participants to control and experimental groups was not feasible. Participants in this study were enrolled in the Computer Science-1 course that is a required university course for all undergraduate students. It is the first course in computer science and has no prerequisites or requirements for any computer skills. However, most of the students have taken courses in computer science in high school and are expected to have good scores on the pretest.

Seven sections of this course are taught. For the purpose of this study, two intact sections were randomly selected and assigned to either a control group (TI; N=46) or an experimental group (TI plus CAI; N=46). A total of 92 students participated in this study. Of the 46 control group participants, 46 were Arab, 22 men and 24 women, and the age range and mean were 18 to 22, 19.20, respectively. And of the 46 experimental group participants, 46 were Arab, 25 men and 21 women, and the age range and mean were 18 to 23, 19.10, respectively. The majority of participants were from low to middle-class backgrounds.

To obtain accurate information, enhance cooperation, and increase the number of volunteers, students and professors were informed that their identity would be confidential. Further, the names of sections from which the data were collected would not be disclosed.

Instrument

To assess students' achievements in the experimental and control groups, the Computer Science-1 Achievement Test (CS1AT) was developed by 8 computer science instructors. The developed CS1AT was based on the university Computer Science-1 placement test and the course objectives. The CS1AT consisted of 50 multiple-choice items and each item had four alternative answers. Each correct answer was worth 1 point, and each incorrect answer was 0 point.

Content validity for the CS1AT was established through a formal review by a panel of 8 instructors as subject matter experts. These experts assessed the test items in terms of the degree of correspondence with the course content. This process resulted in some revisions of the test items without elimination. Prior to this study, the revised version of the test was piloted by a group of students (n=25) to assess the test items difficulty and clarity. The results of the item analysis showed that one item was too easy and was revised. While slight changes were made, no test item was eliminated and 50 test items were retained. The Kuder-Richardson Formula 20 Reliability Coefficient (KR-20) was used to measure the inter-item consistency (Alpha = 0.88). The Pearson Test-retest reliability coefficient was 0.83.

Procedures

This study was conducted during the 2004-05 school year. All participants in both groups completed a pretest before the treatment at the same time and settings. After the pretest, the control group started learning the materials through traditional classroom instruction which included lecture and lab assignments with fifty percent of the time allotted to lecture and fifty percent allotted for lab assignments. The traditional media of chalkboard was used to assist in the presentation of the instructional materials. In contrast, the ITB replaced approximately 20 minutes of the TI for the experimental group in each class meeting of which students completed computerized lessons and exercises. After learning concepts in lecture, the instructor showed the experimental group how to learn more about the concepts using ITB. For instance, students learn the parts of computer hardware from the instructor and then they were instructed to learn in more detail about those parts interactively using ITB.

Each group received an equivalent amount of instructional time. The duration of the study was for a full semester of 16 weeks with three hours of classroom instruction per week. A posttest was given at the end of the semester to both groups. Completion of the course requirements was mandatory for both groups.

Statistical Analysis

In the present study, the covariate was the scores on the pretests; the independent variable was the instructional format, (i.e., TI plus CAI or TI alone); the dependent variable was the scores on the posttest. Descriptive statistics and a one-way analysis of covariance (ANCOVA), using general linear model (GLM) were used to analyze the data. SPSS 13.0 (Statistical Package for Social Sciences) was used to analyze the data. Descriptive statistics were applied to summarize achievement scores (i.e., pretest and posttest) of the course by method of instruction and to verify that the samples were normally distributed.

An ANCOVA was run to determine if group means differed significantly from each other due to the treatment effect not the pre-existing group differences, with the pretest as covariate. Prior to using ANCOVA, assumptions of homogeneous regression coefficients and linearity of Y on X were examined and found to be appropriately met. To evaluate the treatment effects, the effect size was calculated for the instrument. F values were assessed for significance at alpha = 0.05.

RESULTS

Table 1 shows the descriptive statistics of students' achievements scores on the pretest and posttest. No significant difference observed on mean pretest scores between the experimental group (*M*= 30.61) and the control group (*M*=30.96). To adjust for differences in pretest scores ANCOVA was applied using general linear model (GLM). Following the adjustment for the pretest as covariate, the adjusted mean posttest scores was 33.95 for the control group and 39.53 for the experimental group, suggesting that students in the experimental group scored higher on the adjusted posttest than the control group.

Table 1. Mean pretest and mean and adjusted mean posttest scores

Group	N	Pretest		Posttest		
		Mean	SD	Mean	SD	Adjusted Mean
Control	46	30.96	5.90	34.07	9.63	33.95
Experimental	46	30.61	5.17	39.41	4.87	39.53

Note. N=number of students in section

Table 2 shows a significant difference between the two groups for the treatment effect, F (1,89) = 15.554, p =0.000. Thus, the null hypothesis of no significant difference among the adjusted means on the dependent variable was rejected. Overall, the results suggest that the TI plus CAI format is significantly more effective than the TI format alone. The effect size index was calculated from partial eta square ($\eta^2 = 0.149$), which according to Cohen (1988) is a small size effect.

Table 2. Results of ANCOVA on students' posttest scores with pretest scores as the covariates

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pretest	1160.506	1	1160.506	25.294	0.000	22.1%	0.999
Group	713.627	1	713.627	15.554	0.000	14.9%	0.974
Error	4083.450	89	45.881				
Total	5901.739	91					

*$p < 0.05$

DISCUSSION

The purpose of this study was to address the following research question: Is there a significant difference in achievement scores between college students who receive TI plus CAI and those who receive only TI in an introductory computer science course? The results of this study suggest that the TI plus CAI format is significantly more effective than the TI alone format on improving students' achievements which is consistent with the findings of a meta-analysis conducted by Burns and Bozeman (1981).

Furthermore, the results of the present study are consistent with previous meta analysis research that indicate CAI, in general, produces small positive outcomes on students performance at different educational levels (Christmann & Badgett, 2000; Bayraktar, 2001-2002; Kulik & Kulik's, 1991; Waxman, Connell, & Gray, 2002; Yaakub & Finch, 2001; Blok et al., 2002). These findings also support the propositions of instructional theorists in the applications of various instructional strategies, such as the selection of the appropriate delivery medium of instruction, to promote learning (e.g., Bruner, 1966; Merrill, 1971; Briggs, 1977; Gagne, 1979). Instructional theorists have indicated that the selection of the instructional strategies should be based on the theoretical models of the connections between the learner's environment and the internal events of cognition and learning. Since TI plus CAI format provides students with the ability to somewhat control the sequence of the instructional materials, engage their various senses, learn interactively at their own pace, and learn from the instructor, it is likely this format of instruction leads to more meaningful learning and a higher level of achievement than TI format alone. As a result, the TI plus CAI format should be considered as a substitute to the TI alone format.

However, this study has five major limitations that should be noted. First, a convenience sampling was used in which the participants were not randomly assigned to experimental or control groups. Second, the lack of a complete control over the instructors' instructions and the students' learning could have affected the results. Third, only a small size effect was found for group differences in students' overall achievement. Forth, this study involved only a single-institution. Lastly, this is the first known empirical study conducted using CAI with TI in Jordan. Therefore, the results of the study should be interpreted with caution.

Despite the limitations, the findings of this study add to the body of research on the benefits of using CAI with TI. A replication of this study might include more variables and data from other colleges in Jordan. Future studies are needed to explore the effects of CAI on different grade levels and subject areas in Jordan.

Contributor

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References

Alessi, S. M., & Trollip, S. R. (2001). *Multimedia for learning: Methods and development.* Massachusetts: A Pearson Education.

Bandura, A. (1986). *Social foundation of thought and action: A social cognitive theory.* NJ: Prentice-Hall.

Bayraktar, S. (2001-2002). A meta-analysis of the effectiveness of computer-assisted instruction in science education. *Journal of Research on Technology in Education, 34* (2), 173-188.

Blok, H., Oostdam, R., Otter, M. E., & Overmaat, M. (2002). Computer-assisted instruction in support of beginning reading instruction: A review. *Review of Educational Research, 72*, 101-130.

Briggs, L. J. (1977). *Instructional design: Principles and applications*. N. J: Englewood Cliffs.

Brown, K. G. (2001). Using computers to deliver training: Which employees learn and why? *Personnel Psychology, 54* (2), 271-297.

Bruner, J. S. (1966). *Toward a theory of instruction*. MA: Harvard University Press.

Burns, P. K., & Bozeman, W. C (1981). Computer-assisted instruction and mathematics achievement: Is there a relationship? *Educational Technology 21*(10), 32-39.

Center for Social Organization of Schools (1983). *School uses of microcomputers: Reports from a national survey* (Issue no. 1). Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.

Chang, C. Y. (2002). Does computer-assisted instruction + problem solving=improved science outcomes? A Pioneer Study. *The Journal of Educational Research, 95*(3), 143–151.

Chen, L. (2005). Examining the role of computers in EFL instruction. *Electronic Journal for the Integration of Technology in Education, 4*, 30-63. Retrieved February 20, 2006, from http://ejite.isu.edu/chen.pdf

Christmann, E. P., & Badgett, J. L. (2000). The comparative effectiveness of CAI on collegiate academic performance. *Journal of Computing in Higher Education, 11*(2), 91-103.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.).* N.J: Lawrence Erlbaum.

Cook, T. & Campbell, D. (1979). *Quasi-experimentation, design and analysis issues for field settings.* Chicago: Rand McNally.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction (6th ed.).* New York: Longman.

Gagne, R. M. (1985). *The conditions of learning (4th ed.).* New York: Holt, Rinehart and Winston.

Huck, S. W, Cormier, W. H., & Bounds, W. G. (1974). *Reading statistics and research*. New York: Harper Collins.

Jantz, C., Anderson J., & Gould S.M. (2002). Using computer-based assessments to evaluate interactive multimedia nutrition education among low-income predominantly Hispanic participants. *Journal of Nutrition Education & Behavior, 34* (5), 252-261.

Kathleen, C. (1991). Computer-assisted instruction. *School Improvement Research Series (SIRS).* Retrieved February 20, 2006, from NorthWest Regional Educational Laboratory Web site: http://www.nwrel.org/scpd/sirs/5/cu10.html

Kulik, C. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7,* 75-94. Retrieved December 31, 2005, from EBSCO database.

Matheson, D. (2001). Ecologic study of children's use of a computer nutrition education program. *Journal of Nutrition Education, 33*(1), 2-8.

McKethan, R., Everhart, B., & Stubblefield, E. (2000). The effects of a multimedia computer program on preservice elementary teachers' knowledge of cognitive components of movement skills. *Physical Educator, 57* (2), 58-69.

Merrill, M. D. (Ed.). (1971). *Instructional design: Readings.* NJ: Prentice Hall.

Ouyang, J. (1993). *Meta-analysis: CAI at the level of elementary education.* Paper presented at the World Conference on Education Multimedia and Hypermedia, Orlando, FL.

Pagliaro, L. A. (1983). The history and development of CAI: 1926-1981, an overview. *Alberta Journal of Educational Research*, 29(1), 75-84.

Reiser, R. A., & Dempsey, V. J. (2002). *Trends and issues in instructional design and technology.* NJ: Pearson Education.

Smith, P. L., & Ragan, T. (2005). *Instructional design (3th ed.).* NJ: John Wiley & Sons. U.S. Agency for International Development (2004). USAID in Jordan. Retrieved December 20, 2005, from http://www.usaidjordan.org/sectors.cfm?inSector=17

Waxman, H. C., Connell, M. L., & Gray, J. (2002). *A quantitative synthesis of recent research on the effects of Teaching and learning with technology on student outcomes.* Naperville, Illinois: North Central Regional Educational Laboratory

Yaakub, M. N. & Finch, C. R. (2001). Effectiveness of computer-assisted instruction in technical education: A meta-analysis. *Workforce Education Forum, 28* (2) 1-15.

Yildirim, Z., Ozden, Y., & Aksu, M. (2001). Comparison of hypermedia learning and traditional instruction on knowledge acquisition and retention. *The Journal of Educational Research, 94*(4), 207–215.