Assessment of the Usefulness of a Courseware as a Learning Tool for a University Course in Computer Science

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Key words: Courseware development, computer-assisted instruction, teaching in higher education, teaching in computer science

Abstract:

A courseware in Arabic language was developed to investigate the difference between two groups, traditional instruction plus Computer-Assisted Instruction (CAI) versus traditional instruction alone, who were given a pretest and a posttest to measure achievement of an introductory computer science course objectives. A Quasi-experimental, nonequivalent control group design was utilized. An analysis of covariance on the posttest scores with pretest scores as the covariate showed that the traditional instruction plus CAI group performed significantly better than the traditional instruction alone group with a small effect size. It was concluded that traditional instruction plus CAI format should be considered as a substitute to the traditional instruction alone format.

1 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 are not preparing students with a competitive educational foundation to endure the pressures of such a technologically reliant society. According to the USAID (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 very limited to guide researchers, educators, and legislators in Jordan in establishing environments that will promote learning for students. Particularly, there was only one known study conducted by Akour, 2006 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.

2 Review of Literatures

According to Reiser & Dempsey (2002) in 1950s researchers at IBM developed the first Computer-Assisted Instruction (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 (as cited in Reiser et al., 2002) indicated that CAI impact of the 1970s on education is very limited. The Center for Social Organization of Schools (as cited in Reiser et al., 2002) 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 media 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, are controlling the sequence of instructional materials, seeing, hearing, reading, and actively manipulating materials at their own pace.

Throughout the past two decades, a huge 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 were conducted to review and synthesis the outcomes of these studies. Examples of these studies are presented in the following paragraphs.

Waxman, Connell, & 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 traditional instruction was small.

Another study by Blok, Oostdam, Otter, and Overmaat’s study (as cited in Waxman et al., 2002) who examined the effectiveness of CAI programs in supporting beginning readers. They found 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 Kulik and Kulik, and Ouyang (as cited in Waxman et al., 2002) findings.
In a third study, 254 controlled evaluation studies that compared student learning in classes taught with and without computer-based instruction were examined (CBI) (Kulik & Kulik’s, 1991). Results indicated that CBI usually produces positive effects on students. In a forth study, compared the effectiveness of CAI with traditional instruction 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 (Yaakub & Finch, 2001). In a fifth study, Burns & Bozeman (as cited in Kathleen, 1991) examined 40 studies that compared the effectiveness of traditional instruction alone with a combination of traditional instruction and CAI on students' mathematics achievement. The results indicated that the combined traditional CAI approach was significantly more effective.

In a sixth study, 18 studies at the college level were examined for the effectiveness of CAI and found an overall mean effect size of 0.127. The results indicated that students who received traditional instruction supplemented with CAI performed slightly better than those who received only traditional instruction and that CAI was most effective in aviation and English and least effective in mathematics and music (Christmann & Badgett, 2000). In a seventh study, 42 studies that involved college students were examined for the effect of CAI on students achievement in science education when compared to traditional instruction and found a small effect of .27 (Bayraktar, 2001-2002). Finally, Akour (2006) compared the effectiveness of traditional instruction alone with a combination of traditional instruction and CAI on students' computer science achievement. The results indicated that the combined traditional CAI approach was significantly more effective. Based on this research review, it is anticipated in this study that students who receive traditional instruction plus CAI would perform better than those who receive only traditional instruction.

Overall, most of the CAI research studies reported small positive effect of CAI on the achievement of students at different educational levels and most them were done in the United States of America. 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 traditional instruction plus CAI and those who receive only traditional instruction in an introductory computer science course? Based on this research question, the null hypothesis was declared that there was no significant difference among the adjusted means on the dependent variable.

3 Method

3.1 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 pretest and 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 75 and 73 (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. The nonequivalent control group design is illustrated in the following diagram:
In depth description concerning the educational courseware development, participants, instrument, procedures, and statistical analysis are presented in the following paragraphs.

3.2 Educational Courseware Development

Designer of instructional interactive multimedia should base the development of materials on the behavioral, cognitive, and constructivist approaches. These approaches proposed 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's, 2001).

To develop the educational courseware entitled "Information Technology for Beginners" (ITB) Version 1.0, the researcher designated a team of three computer programmers, one instructional designer, four 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 & 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 many lessons, interactive exercises, summary, and 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 learners participations and address their 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 go within 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 questions achievement tests generated randomly and provided immediate feedbacks to the learners regarding their achievement test scores. During its development it was subjected to a formative evaluation by an expert review panel and a student review panel. Summative evaluation was also conducted by a pilot study using a quasi-experimental design.

3.3 Participants

The convenient sample consisted of college students at the Al Al-Bayt University, Mafraq, Jordan. To improve the generalizability of the study, the researcher attempted to obtain a sample that was large and diverse. Random assignment of students to control and experimental groups was not feasible. Participants in this study were enrolled in the Computer...
Science-1 course that is a university required 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. It was divided into seven sections. For the purpose of this study, two intact sections were randomly selected and assigned randomly to either a control group (traditional instruction; N=42) or an experimental group (traditional instruction plus CAI; N=42). A total of 84 students participated in this study.

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.

3.4 Instrument

To assess students' achievements in the experimental and control groups, the Computer Science-1 Achievement Test (CS1AT) was developed. 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 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 therefore was revised. As a result, no test item was eliminated and the 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.

3.5 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 being lecture and fifty percent 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 traditional instruction 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 are instructed to learn in more details 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.

3.6 Statistical Analysis

In the present study, the covariate was the scores on the pretests; the independent variable was the instructional format, (i.e., traditional instruction plus CAI or traditional instruction alone); the dependent variable was the scores on the posttest. The statistics that
were applied to analyze the data consisted of descriptive statistics and a one-way analysis of covariance (ANCOVA), using general linear model (GLM). 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 are normally distributed. To deal with the main threat to the internal validity of a nonequivalent control group design, ANCOVA was applied to decide 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.

4 Results

Table 1 shows the descriptive statistics of students’ achievements scores on the pretest and posttest. No significant difference noticed on mean pretest scores between the experimental group ($M= 15.07$) and the control group ($M=15.71$). 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 35.03 for the control group and 41.49 for the experimental group, suggesting that students in the experimental group scored higher on the adjusted posttest than the control group.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pretest Mean</th>
<th>Pretest SD</th>
<th>Posttest Mean</th>
<th>Posttest SD</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>42</td>
<td>15.71</td>
<td>3.93</td>
<td>35.43</td>
<td>11.59</td>
<td>35.03</td>
</tr>
<tr>
<td>Experimental</td>
<td>42</td>
<td>15.07</td>
<td>3.40</td>
<td>41.10</td>
<td>7.26</td>
<td>41.49</td>
</tr>
</tbody>
</table>

Note. N=number of students in section

Table 2 shows a significant difference between the two groups for the treatment effect, $F (1,81) = 11.767, p =0.000$. Thus, the null hypothesis of no significant difference among the adjusted means on the dependent variable is rejected. Overall, the results suggest that the traditional instruction plus CAI format is significantly more effective than the traditional instruction format alone. The effect size index was calculated from partial eta square ($\eta^2 = 0.127$), which according to Cohen (1988) is a small size effect.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1682.810</td>
<td>1</td>
<td>1682.810</td>
<td>22.775</td>
<td>0.000</td>
<td>21.9%</td>
</tr>
<tr>
<td>Group</td>
<td>869.500</td>
<td>1</td>
<td>869.500</td>
<td>11.767</td>
<td>0.001</td>
<td>12.7%</td>
</tr>
<tr>
<td>Error</td>
<td>5985.095</td>
<td>81</td>
<td>73.890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8342.238</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p < 0.05$

5 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 traditional instruction plus CAI and those who receive only traditional instruction in an introductory
computer science course? The results of this study suggest that the traditional instruction plus CAI format is significantly more effective than the traditional instruction alone format on improving students' achievements which is consistent with Akour (2006) and Burns & Bozeman (as cited in Kathleen, 1991) meta-analysis findings.

Furthermore, the results of the present study are consistent with previous meta analysis research that found 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, Oostdam, Otter, and Overmaat's study (as cited in Waxman et al., 2002)) and 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). 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 traditional instruction plus CAI format provides students with the opportunity to some control over the sequence of the instructional materials, engages 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 higher level of achievement than traditional instruction alone format. In addition to the aforementioned, the substantiated design of the ITB courseware may have a positive effect on achievement. As a result, the traditional instruction plus CAI format should be considered as a substitute to the traditional instruction alone format.

However, this study has four 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 second known empirical study conducted using CAI with traditional instruction in Jordan. Therefore, the results of the study should be interpreted with precaution.

Despite the limitations, the findings of this study add to the body of research on the benefits of using CAI with traditional instruction. 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.

References:


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