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The Effect on Students' Achievements of Computer Assisted Instruction Designed for Quadratic Functions

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Abstract

The purpose of this study was to investigate the effect on students' achievement of computer-assisted instruction (CAI) environment designed for quadratic function (QF). In this study was used a quasi-experimental method, which was a quantitative research approach. The participants of the study consisted of 30 tenth grade students from two different classes. SPSS statistical program was used for data analysis. Comparisons of the experimental and traditional groups were made by dependent samples t-test, while independent samples t-test was used for comparisons between the groups. Results showed that CAI was more effective than the traditional teaching method in terms of achievement. There was a significant difference between the QF achievement scores of the pretest and posttest of the experimental and traditional groups. This research was limited to the subject of QF in a mathematics course. Within the context of contemporary approaches, similar researches can be conducted on other subjects that are challenged in a mathematics course for the design and evaluation of learning environments based on CAI materials.

Keywords: *Quadratic functions, computer-assisted instruction, students' achievement.*

Introduction

Development and expansion of computer technology, both educators and schools that started to design new learning-teaching environments. Computer technologies in schools were initially thought to be a tool to support the lesson described by teachers just like overhead projectors, slides and videos (Chalmers, 2000; Baki, 2002). Contrary to the traditional approach, educators desire to the computer not only as an instructional tool, but also as a learning tool. With the introduction of computers in the education, the concept of Computer Assisted Instruction (CAI) has emerged (Lewis & Cooney, 1987; Baki, 2002).

The roles of technology in mathematics education have changed teaching and learning (Donnelly-Hermosillo, Gerard, & Linn, 2020). The use of technology-supported tools and computer-aided activities in mathematics teaching is recommended (National Council of Teachers of Mathematics [NCTM], 2000; Association of Mathematics Teacher Educators [AMTE], 2006). Computer algebra systems, electronic spreadsheets and graphical software programs are the software that can perform mathematical operations, numerical and symbolic calculations, and enables the representation of two and three dimensional graphs (Donnelly-Hermosillo, etc., 2020; Hoyles & Noss, 1994). It is valid in Coypu and Derive programs. In the researches carried out from 1990s to 2000s, computers were used as a demonstration tool in some studies within the goal of computer-aided instruction (Wakil, Khdir, Sabir, & Nawzad, 2019), some studies the goal of computer programme. There are studies that examine the effect of CAI on students' achievements and attitudes according to traditional teaching and include practice and repetition programs and commercial software and using Basic, Cobol, Qbasic, Visual Basic and Logo software as

software. After the 2000s, in the researches carried out within the goal of computer-aided teaching, it is seen that there are still studies that use computers as a demonstration tool. Many studies were conducted in different levels and learning areas of mathematics in order to examine the effect on cognitive or affective domains of CAI. They focused on different software designs in these researches. For instance, some researchers have used dynamic computer software such as Geometer's Sketchpad, Logo, Cabri. Some researchers have done using programs such as Excel, Coypu, GeoGebra, Logo, Derive, Maple, Mathematica etc. various research in the fields of Algebra and Functions. Excel, Logo, Autograph and commercial software programs were used especially at primary level (1-8th grade). In addition, Derive, Visual Basic, Excel, Logo programs were used in secondary education (9-12th grade). The studies which using these programs focused on success, attitude, students' or teachers' views. However, no study has been found in Turkey to design and implement in which learning environment using student and teacher guidance materials developed with the help of Coypu, Derive and Excel programs in high school mathematics teaching. Therefore, in order to integrate computer technology into high school mathematics curriculum and to contribute to the literature, research involving computer programs should be included.

Many studies have been conducted to examine the effect of CAI on functions and graphs. Their studies focused on various software, methods and examined the effects of learning functions and graphs (Bos, 2005; Gebrekal, 2007; Zengin & Tatar, 2017; Çetin & Mirasyedioğlu, 2019). Gebrekal (2007) determined that teaching using Excel and RJS graphics software increased students' achievement, positively affected their attitudes towards mathematics, and problem solving skills. Bos (2005) examined the effect of interactive software used in Texas Instruments teaching environment on mathematics achievement of eleventh grade students with low levels of success in teaching the subject of second order functions. Buran (2005) examined the comparison of the efficiency levels of technology-assisted and traditional teaching methods in the teaching of Quadratic Function (QF) with realistic problem situations. Limited number of studies showing that CAI is more effective than traditional teaching method in students' learning of QF (Bos, 2005; Zengin & Tatar, 2017).

When the mentioned studies were evaluated, it was seen that the effect of CAI on students' achievements and attitudes in teaching some subjects in mathematics was utilized in different levels in order to determine students' and candidate teachers' opinions about computer assisted instruction. It was conducted that some of these studies (Işıksal & Aşkar, 2005; Tienken & Maher, 2008) with students in the middle school, some studies (Nwaubeze, 2006) with university students and in some studies (İbili, 2019) with mathematics teachers. However, limited numbers of studies (Neurath & Stephens, 2006) have been found in which Excel software is applied to high school students.

When the studies on the effect of CAI on students' achievement were examined, it was found that different research results showed that CAI affects the mathematics achievements. In some studies (Gebrekal, 2007; Tienken & Wilson, 2007; Çetin &

Mirasyedioğlu, 2019), it was found that there was a significant difference in mathematics achievement scores in favor of computer-assisted students. On the other hand, it was concluded that there was no significant difference between computer-assisted teaching group and traditional teaching group in terms of mathematics achievement scores (Tienken & Maher, 2008). QF is an essential issue that bridges the understanding of subsequent issues in mathematics. In the literature, it is stated that the majority of students are experiencing some difficulties in learning (Zaslavsky, 1997; Sajka, 2003; Zazkis, Liljedahl & Gadowsky, 2003; Ubah & Bansilal, 2018; Wilkie, 2019). Not only is the quadratic function an important concept in a college algebra or other introductory mathematics courses, but it is also important in calculus courses (Burns-Childers & Vidakovic, 2018). Many studies have been conducted in different levels and on different subjects of mathematics to examine the effect of CAI on students' achievement. In this study, learning environment was designed using Coypu, Derive and Excel softwares to teach the QF in the tenth grade mathematics curriculum. For this purpose, computer aided teaching materials were developed and applied in tenth grade mathematics course. The purpose of this study is to investigate the effect on students' achievement of CAI environment designed for quadratic function.

Method

Research Model In this study was used a quasi-experimental method, which was a quantitative research approach. A quasi-experimental design is adopted in cases in which experimental and traditional groups are not formed randomly. Two groups were formed in the study. Measurements were applied to these groups before and after teaching. Computer assisted learning method was used in the experimental group and traditional teaching methods were used in the traditional group. In this design, both intergroup and intragroup were compared to find answers to research problems. In the research, the experimental and traditional groups were given the mathematics achievement test as a pre-test before the experimental procedures and as a post-test at the end of the application.

Participants

Participants of this study consisted of 30 tenth grade students from two different classes. These students had never seen QF and computer software before. The scores of the ninth grade mathematics course grades, QF and inequalities, and the scores obtained from the achievement test on QF in grading the tenth grade students were examined. Accordingly, 15 students in the experimental group and 19 students in the traditional group were subjected to equalization process. In the equalization process, the scores of the students were taken as a result of the pre-test of the grade determination exam grade including the gains in the grades of QF and inequalities, and the grades of QF. Students whose grades are not equivalent are excluded from the study. For this reason, the data of four students in the traditional group were excluded from the study. As a result, the study group consisted of a total of 30 students, 15 of whom were experimental and traditional groups.

Data Collection Tool

The following steps were performed to prepare the mathematics achievement test for the QF. First of all, the acquisitions of QF were examined in the high school

mathematics curriculum. In order to achieve this, exams, mathematics textbooks and question banks were examined and experimental items were formed to consist of multiple choice questions. These items were consulted by five mathematics teachers and two experts in mathematics education in terms of compliance with the measurement and evaluation principles for construct validity. The test consisted of 30 questions was prepared according to the opinions.

Opinions of experts and teachers were obtained for the validity of the test. This achievement test was applied to 50 eleventh grade students. There are five options for each question in the achievement test. At the end of the test, item analyzes were performed. In item analysis, difficulty and discrimination indices of each item were calculated. Substances were excluded from the test with index of discrimination below .20. In addition, some questions are excluded from the test that is suggested to be corrected. The Cronbach's Alpha coefficient, which is the measurement reliability of the achievement test, was found to be .88. The Pearson and Spearman-Brown coefficients for dividing the test into two halves were .72 and .83. These values indicate that the reliability of the success test can be accepted as reliable.

Data Analysis

SPSS statistical program was used for data analysis. Comparisons of the experimental and traditional groups were made by dependent samples t-test, while independent samples t-test was used for comparisons between the groups. The relationship between the pre-test and post-test scores applied to the experimental group was investigated with the effect of one-way ANOVA (Repeated Measurements). The homogeneity of variance of the data was investigated and was analyzed. For this purpose, Levene test was performed. It was found that the variances were homogeneous if the p values obtained were greater than 0.05. Since there were 30 students in these study group, Shapiro-Wilk facility was used to determine whether the tests were normally distributed. In the analysis of the data, the answers of the students to each question in the QF mathematics achievement test were examined. The answers were evaluated in three categories as "right", "partially right", "wrong or unanswered". 10 points if the answer is correct, 5 points if partially correct, zero 0 points if given wrong or unanswered. The highest score is 100 from the achievement test.

Finding

Shapiro-Wilk test was used to determine whether the pre-test and post-test scores of the groups showed normal distribution. Whether the score distribution of the achievement test is appropriate for the normal distribution can be found in Table 1.

Table 1.

The results of shapiro-wilk tests of achievement test applied to experimental and traditional groups

Groups	Test	S	SW	p
Experimental group	**Pre-test**	12,22	.966	.793
	Post-test	13,28	.915	.161
Traditional group	**Pre-test**	10,47	.976	.933
	Post-test	17,23	.892	.071

p>.05

As shown in Table 1, pre-test (SW = .966, p> .05), pre-test traditional (SW = .976, p> .05) of Shapiro-Wilk test results applied to pre-test and post-tests in experimental and traditional groups. Post-test experiment (SW = .915, p> .05), post-test traditional (SW = .892, p> .05) scores p> .05 was found to be normal distribution. According to these results, parametric tests were used in the analysis of achievement test scores.

The pre-test and post-test mean scores and standard deviation values of the students' mathematics achievement test according to the groups (experiment-traditional) and measurements (pretest and posttest) of the achievement scores in the second order functions sub-learning area of experimental group and traditional group students are given in Table 2.

Table 2

Pre-test and post-test mean scores and standard deviation values of students from mathematics achievement test

Groups	**Pre Test**			**Post Test**		
	n	$\overline{x}$	**sd**	**n**	$\overline{x}$	**sd**
Experimental group	15	32,66	12,22	15	77,73	13,28
Traditional group	15	31,06	10,47	15	60,13	17,23

In Table 2, the mean mathematics achievement scores of the students using the computer assisted teaching method before the experiment $\overline{X}$ = 32,66, while this value was found to be $\overline{X}$ =77,73 after the experiment. The average of the pre-experiment scores of the students in the traditional group in which traditional expression methods were applied $\overline{X}$ = 31,06, after the experiment $\overline{X}$ = 60,13. According to these results, it was found that there was an increase in the average scores of the experimental group mathematics achievement test scores using computer-aided instruction and the traditional group scores where traditional teaching method was applied. However, it was observed that the mathematics achievement averages of the experimental group students increased higher than the traditional group. Levene test was used to determine whether the variances of pre-test and post-test scores were equal and the data obtained are presented in Table 3.

Table 3

Homogeneity test of variances

	Levene Statistics	**Sd_1**	**Sd_2**	**p**
Pre test	.396	1	28	.534
Post test	2.399	1	28	.133

As shown in Table 3, the pre-test [$F_{(1-28)}$ = 0,396, p> .05] and post-test [$F_{(1-28)}$ = 2,399, p> .05] scores of the groups were p> .05 and the variances were equal. In this respect, two-way analysis of variance (ANOVA) was performed to determine whether the change in the pre-test and post-test mean scores of the experimental and traditional groups was significant. The results of the two-way analysis of variance regarding whether the changes observed in the mathematics achievement scores of the students compared to the pre-experiment and after the experiment are shown in Table 4.

Table 4

ANOVA results of the pre-test and post-test achievement scores of the experimental and traditional groups

Source of Variance	Sum of squares		Mean squares	F	p
Intergroup	**9066,4**	**29**			
Group (Experimental/Traditional)	1382,400	1	1382,400	5,03	.033
Error	7684,000	28	274,429		
Inter-group	**24140,000**	**30**			
Measurement (Pretest-posttest)	20609,067	1	20609,067	224,45	.000
Group* Measurement	960,000	1	960,000	10,45	.003
Error	2570,933	28	91,819		
Total	**33206,4**	**59**			

In Table 4, a significant difference was found between the pretest and posttest total achievement scores of the experimental and traditional groups [$F_{(1-28)} = 5,03$, $p < 0.05$]. This finding shows that the achievement scores of the students in the experimental and traditional groups differ without making a measurement distinction (before and after the experiment). There is a significant difference between the pre-test and post-test average achievement scores of students regarding QF success [$F_{(1-28)} = 224,45$, $p < 0.05$]. This finding can be interpreted as the QF achievement of the students, regardless of group discrimination, depends on the teaching model applied.

Table 4 shows that the scores of the achievement test scores of the experimental and traditional group students using two different teaching methods differ significantly from the pre-experiment to the post-experiment, in other words, the common effects of repeated measurement factors on the achievement levels in the second-order functions sub-learning area are significant. [$F_{(1-28)} = 10,45$, $p < 0.05$]. This finding shows that teaching with CAI increases the achievement of students compared to traditional teaching. In other words, the QF achievements of the students in the experimental and traditional groups differ in favor of the CAI group. The achievement scores of the students in the experimental and traditional groups change as a result of the experimental process applied. It is possible to interpret the reason of the differences observed in the achievement of the students in the experimental group from the CAI and practising designed based on the constructivist approach. In the QF achievement test, pre-test scores were lower than post-test scores, and it could be interpreted that the course with CAI was more effective in increasing students' achievement. The changes in the mean scores of the pre-test and post-test of the experimental and traditional group students are given in Figure 1.

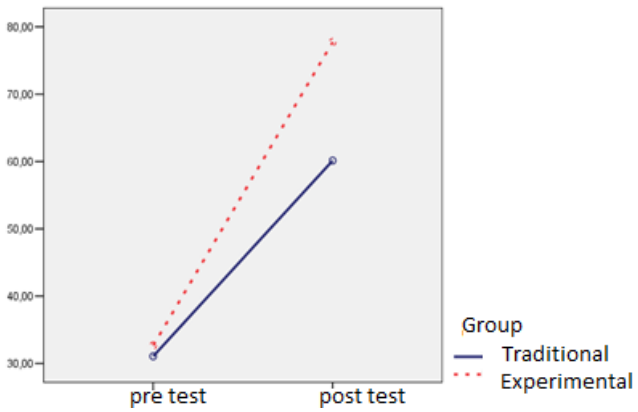

Figure 1*The change in the pretest-posttest achievement scores of the experimental and traditional group students in QF subject*

In Figure 1, the achievements of the students in the traditional group where QF was studied by traditional methods were lower than the experimental group where the worksheets prepared based on constructivist approach and the course based on computer-assisted instruction were taught.

Discussion and Conclusion

The experimental and the traditional groups students' achievement scores on QF according to the groups (experiment-traditional) and measurements (pretest and posttest) according to the pretest-posttest mean score and standard deviation values of the students according to the pre-test and post-test values of the experimental group students, the average score of the QF on the subject before the experiment $\overline{X}$ = 32,66 $\overline{X}$ = 77,73 after the experiment. The mean pre-experiment scores of the students in the traditional group in which teacher centered teaching methods were applied $\overline{X}$ = 31,06, and after the experiment $\overline{X}$ = 60,13.

According to these results, it was found that there was an increase in the average scores of the experimental group achievement test scores using computer assisted instruction and the traditional group scores where teacher centered teaching method was applied. However, it was observed that the achievement averages of the experimental group students increased higher than the traditional group.

CAI is more effective than traditional teaching method in terms of achievement. In the studies conducted, it is emphasized that computer assisted teaching method is more effective in terms of success than traditional teaching (Liao, 2007; Zengin & Tatar, 2017; Çetin & Mirasyedioğlu, 2019). Tienken and Wilson (2007) examined the effect of CAI on mathematics achievement of students. They found a positive effect although CAI has a low impact on mathematics achievement. In contrast, in Liao's (2007) meta-analysis study, although some studies on computer-assisted teaching and traditional teaching stated that there are benefits of the use of CAI in education, some studies indicate that there is no significant difference between them (Liao, 2007).

There was a significant difference between the QF achievement scores of the pretest and posttest of the experimental and traditional groups [$F_{(1\text{-}28)}$ = 5,03, p <0.05]. This finding shows that the QF achievement scores of the students in the experimental and traditional groups differ

without making a measurement distinction (before and after the experiment). This finding can be interpreted as the QF achievement of the students, regardless of group discrimination, depends on the teaching model applied. According to this result, the significant difference between the achievement post-test scores of the experimental and traditional groups shows that the learning environment made with computer-based teaching materials based on the constructivist approach applied in the experimental group is more effective on the academic achievement of the students than the traditional learning environment applied in the traditional group. This result obtained from this study contradicts the results of other studies (Klein, 2005).

It was found out that the QF test scores of the experimental and traditional group students using two different teaching methods showed significant differences from the pre-experiment to the post-experiment, or in other words, it was found that the common effects of repeated measurement factors on QF achievement levels were significant [$F_{(1-28)}$=10,45, $p<0.05$].

This finding shows that the learning environment in which CAI materials are applied and the traditional learning environment in which flat expression and question and answer method are applied, have different effects on increasing students' achievement in QF. As a result of the experimental process applied, students' success in QF is changing. It is possible to interpret the reason of the differences observed in the students' achievement as the first application for the experimental group students and the processing of the course with computer-assisted teaching applications designed based on the constructivist approach.

The students had a better and more meaningful learning experience in this dynamic and interactive process. These interactive, dynamic meaningful learning experiences have been found to increase students' achievement. This result is similar to the results of some of the researches that computer-assisted instruction increases student achievement (Adelabu, Makgato, Ramaligela, 2019a; Gebrekal, 2007; Tienken & Wilson, 2007; Zengin & Tatar, 2017). In some studies, it was concluded that there was no significant difference between computer-assisted teaching group and traditional teaching group in terms of achievement scores (Tienken & Maher, 2008).

One of the important factors on the success of students who have seen CAI may be the use of materials prepared in Coypu, Derive and Excel in teaching of quadratic functions. These programs are very flexible as they allow the user to enter and monitor various data. This structure of the program allows the student to discover and establish new information about quadratic functions and graphs. With the help of the material, it is possible to show the students' abstract concepts on this subject and to enable them to visualize the graphics in two dimensions. This result is similar to the result of some of the research indicate that graphing technologies effect learning of mathematics topics as well as graphing itself (Donnelly-Hermosillo, etc., 2020).

Some studies have been conducted in the literature to determine the effectiveness of computer-assisted teaching. In their studies, students stated that computer-aided teaching method had higher student achievement compared to traditional

teaching method and that the concepts taught with this approach were learned more effectively by the students (Tienken & Wilson, 2007; Yücel & Mirasyedioğlu, 2019). In addition, some researchers have stated that computer-aided education not only improves success, but also enables students to develop high-level thinking skills, and as a result, students learn more by heart than by memorization (Adelabu, Makgato, Ramaligela, 2019b; Ismajli & Krasniqi, 2018; Liao, 2007).

It was found that there was an increase in the mean scores of the experimental group achievement test with which CAI was applied and the mean scores of the traditional group where the traditional teaching method was applied, but the achievement averages of the experimental group students were higher than the traditional group. It was concluded that there was a significant difference between the pre-test and post-test second order functions of the experimental group in the learning environment in which constructive approach based CAI materials were applied, and the traditional group in the traditional learning environment in which the flat expression and question and answer method was applied.

The achievement scores of the QF test of the experimental and traditional group students using two different teaching methods showed a significant difference before and after the experiment. In other words, it was found that the common effects of repeated measurement factors on achievement levels of QF were significant in different process groups (experiment and traditional).

Suggestions

This research is limited to the subject of QF in mathematics course. Within the context of contemporary approaches, similar researches can be conducted on other subjects that are challenged in mathematics course for the design and evaluation of learning environments based on CAI materials.

In this study, the effectiveness of the CAI method, which was designed based on the constructivist approach, was compared with the traditional method. By comparing the effectiveness of teaching according to the CAI method with the studies based on other contemporary approaches and teaching methods, it can be determined what results are reached. In this context, contemporary approaches and teaching methods can be examined together and their advantages and deficiencies can be revealed.

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