Croatian Journal of Education
Vol.17; No.3/2015: pages: 783-813
Original research paper
Paper submitted: 21st September 2013
Paper accepted: 9th April 2014
doi: 10.15516/cje.v17i3.1075

The Effect of Computer-Assisted Instruction on 7th Grade Students' Achievement and Attitudes toward Mathematics: The Case of the Topic "Vertical Circular Cylinder"

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Abstract

The purpose of this study was to investigate the effect of computer-assisted instruction (CAI) regarding concepts of "surface area and volume of vertical circular cylinder" on seventh grade students' achievement and attitudes toward mathematics. A pre-test and post-test control group with quasi-experimental study design was used. This research was carried out with 49 seventh grade Turkish students (24 students in the experimental group, and 25 students in the control group). The students in the experimental group were taught with CAI, while the students in the control group were taught in the traditional way (textbook-based direct instruction). The "Mathematics Achievement Test (MAT)" and the "Mathematics Attitude Scale (MAS)" were administered to both groups as a pre-test and a post-test. The data were analyzed with multivariate analysis of variance (MANCOVA). The results indicated that CAI significantly improved students' mathematics achievement compared to the results achieved through traditional instruction. However, it was found that short-term CAI implementation did not make a significant difference on students' attitudes toward mathematics.

Key words: *attitudes toward mathematics; computer-assisted instruction (CAI); mathematics achievement; mathematics education; seventh grade student.*

Introduction

The last two decades have witnessed a tremendous change in the role of technology in mathematics classes. This change is clearly present in the reports of the National Council of Teachers of Mathematics (NCTM). In the report called *Professional Standards for Teaching Mathematics* (NCTM, 1991), calculators and computers were regarded as the instruments to be utilized in improving students' mathematical communication and reasoning. *Principles and Standards for School Mathematics* (NTCM, 2000) also stated that using technology appropriately in mathematics lessons offer students a practical and active learning experience, which provides better understanding and concrete learning. Additionally, the Turkish Primary Mathematics Curriculum, which was put into practice in 2005, suggested the necessity of using technology efficiently in learning and teaching mathematics (MoNE, 2005). In this context, Turkish Ministry of National Education (MoNE) aims to equip all 40,000 schools and 620,000 classrooms with technological appliances (tablets, computers, smart boards, projectors, Internet connection, etc.) until 2023 (Işıklı, Bozkurt, & Birgin, 2012).

Computers are useful not only for their calculation abilities but also for making the abstract concepts concrete on the screen and for facilitating the learning process (Baki, 2002). As a matter of fact, many of the recent studies proved that computer-assisted instruction (CAI) has a positive effect on students' learning and achievements regarding mathematical concepts (Baki, Kösa, & Güven, 2011; Baki & Çakıroğlu, 2011; Barkatsas, Kasimatis, & Gialamas, 2009; Birgin et al., 2008; Erbas & Yenmez, 2011; Gürbüz & Birgin, 2012; Işıksal & Aşkar, 2005; Özdemir, Tektaş, & Egelioğlu, 2010; Pilli & Aksu, 2013; Tabuk, 2003; Tjaden & Martin, 1995; Tutak & Birgin, 2008; Ubuz, Ustun, & Erbas, 2009; Qing & Xin, 2010; Yıldız, 2009). Işıksal and Aşkar (2005) investigated the effect of CAI consisting of Excel and dynamic geometry software (Autograph) compared to traditional instruction with regard to the coordinates of a point on a plane, symmetry and straight line chart. The results of the study showed that mathematical achievement of the group that was taught with the help of dynamic geometry software was significantly higher than that of the group taught in the traditional way and with Excel software. Özdemir et al. (2010) found out that teaching transformation geometry and areas of tetragonal areas in seventh grade with CAI compared to traditional instruction is more effective. Similarly, it was determined that CAI was more successful than traditional methods in teaching straight line graphs (Birgin et al., 2008), circle, circular region and cylinder (Tabuk, 2003), angles and rectangles (Bedir, 2005), and polygons (Erbas & Yenmez, 2011) at the primary school level. As a result of meta-analysis of CAI studies conducted by Qing and Xin (2010) and carried out between kindergarten and twelfth grade, it was determined that CAI has a positive effect on students' mathematical achievements. Yeşilyurt (2000) also conducted a meta-analysis of studies regarding CAI implemented between 2000 and 2008 in the field of science and mathematics, which resulted in proving that CAI has positive effects on students' achievements.

At the same time, many of the studies investigating the effect of CAI on students' attitudes toward mathematics showed that computer technologies affected students' attitudes positively (Aktümen & Kaçar, 2008; Aliasgari, Riahinia, & Mojdehavar, 2010; Baki & Güveli 2008; Barkatsas et al., 2009; Bedir, 2005; Duru, Peker, & Birgin, 2012; Funkhouser, 2002; Gürbüz, Çatlıoğlu, Birgin, & Toprak, 2009; Güven, 2002; Hangül & Üzel, 2010; Işıksal & Aşkar, 2005; Köklü & Topçu, 2012; Lopez-Morteo & Lopez, 2007; Pilli & Aksu, 2013; Seo & Bryant, 2009; Yıldız, 2009). In this context, Hangül and Üzel (2010) found that CAI improved eighth grade students' attitudes toward mathematics compared to traditional instruction while teaching "geometric objects". Baki & Güveli (2008) determined that using computer-assisted materials also has a positive effect on students' attitudes toward mathematics. Güven (2002) also reached that conclusion by employing Cabri, a dynamic geometry software, to teach seventh grade geometrical topics of mathematics courses. His findings showed that CAI affected students' comprehension of geometry positively. Similarly, a study conducted in secondary school by Akinsola and Animasahun (2007) showed that the CAI based simulation-game environment group had more positive attitudes toward mathematics than the traditionally taught group. In a meta-analysis conducted by Santally, Boojawon and Senteni (2004), it was determined that CAI increases students' motivation for learning mathematics and contributes to their development of a positive attitude toward mathematics.

Some studies showed that many Turkish primary and secondary school students were afraid of geometry subjects and they did not like them generally. As a matter of fact, the achievement average in geometry for Turkish students who participated in the Trends in National Mathematics and Science Study (TIMSS) between 1999 and 2007 was below the international average. Turkish students ranked 34th among 38 countries in the field of learning geometry according to TIMMS 1999 (MoNE, 2003) and they ranked 46th among 56 countries in TIMSS 2007 (MoNE, 2011). Additionally, when looking at the achievement points of Turkish students regarding geometry comprehension in terms of TIMSS 1997 and 2007, it was seen that there was a significant decrease of 7 points in 2007. These results indicated that Turkish students were having particular difficulty in learning geometry.

In geometry courses, students learn characteristic features and the relations among them regarding geometric shapes and structures. Spatial visualization - thinking of two or three dimensions of a geometric shape in space - and looking at various aspects are the most important parts of geometric thinking (NCTM, 2000). Expression 'dynamic geometry software' is the common name of very special geometry software developed for Geometer's Sketchpad, Cabri Geometry, Cinderella, and GeoCebra. Dynamic geometry software has allowed students to hypothesize, explore the theorems and relations, and test them by rescuing the geometry from the static paper and pen process and making it dynamic on a computer screen (Güven & Karataş, 2003). The reports of the NCTM (2000) and the New Turkish Primary Mathematics Curriculum also stated that concrete materials, drawings, and dynamic geometry software are necessary to learn geometry (MoNE, 2005). Dynamic geometry software (e.g.

Geometer's Sketchpad, Cabri, Cinderella or GeoCebra) facilitates students' process of establishing relationships between geometric shapes and making inferences.

Dynamic geometry software is a potentially powerful tool for students to learn geometry concepts in a dynamic and engaging way. With this software, the properties of geometric objects and relationships between figures in two dimensional spaces can be examined (Keşan & Çalışkan, 2013). Interactive two- and three-dimensional graphics embedded in geometry software also allow students to visually explore the properties of geometric shapes and help them understand geometric relationships (Sea & Woo, 2010; Steen, Brooks, & Lyon, 2006). Researchers have also shown that geometry software works because it has dynamic features and it gives the students the opportunity to concentrate on much more abstract structures than the widely used paper-pen studies (Baki, Kösa, & Güven, 2011; Erbas & Yenmez, 2011; Hazan & Goldenberg, 1997; Işıksal & Aşkar, 2005; Tutak & Birgin, 2008; Yıldız, 2009). In this way, students' power of imagination increases and they will be able to analyze, hypothesize, and generalize. This situation will directly develop students' problem-solving skills (Baki, 2002). With this new approach, students have the opportunity to explore, make assumptions, test, reject, formulate, and explain various aspects by easily entering the research environment (Güven & Karataş, 2003). In geometry teaching, through the use of dynamic geometry software, students can create geometric drawings or do interactive investigations of the dynamic geometric shapes prepared by the teacher (MoNE, 2005).

This study focused on the 7th grade mathematics topic "*surface area and volume of vertical circular cylinder*". This topic also provides a basis for another topic, "*surface areas and volumes of geometrical objects*" in Turkish eighth grade mathematics curricula. These topics are remarkable in terms of their three dimensions. Due to the visuality and explorative environment presented for comprehensive students' learning, application of computer technologies is thought to be beneficial. Because of the three-dimensionality of the material, it would be useful to explore the effect of using computer technologies to teach topics such as surface area and the volume of vertical circular cylinders on students' attitudes and achievements. The purpose of this study is to determine the effect of using computer technologies to teach surface area and volume of vertical circular cylinder on 7th grade students' achievements and attitudes toward mathematics. To this end, we tried to answer the questions listed below:

Is there a significant difference between the achievement test scores of the students exposed to CAI and those who were exposed to traditional instruction (TI) with textbooks only?

Is there a significant difference between the mathematics attitude scale scores of the students exposed to CAI and those who were exposed to TI with textbooks only?

Methods

In this study, a quasi-experimental model with a pre-test and post-test was employed. Quasi-experimental models are generally preferred when students cannot be appointed to experimental and control groups randomly (Çepni, 2008). Hence, groups were selected among the 7th grade classes in the public primary school where we decided to implement the study. The natural classroom environment was protected since a random appointment could not be performed due to the structures of the current school. One of these groups, which was selected randomly, was appointed as the control group while the other one was the experimental group. The experimental group was exposed to computer-assisted instruction (CAI) while the control group was not intervened with and it continued with traditional instruction (textbook-based direct instruction). This quasi-experimental research was implemented during the 2010-2011 academic year in the spring term.

Participants

The sample of participants in this study consisted of 49 seventh grade students from a state primary school in the suburban district of Uşak, Turkey. The control group consisted of 25 seventh grade students (14 female, 11 male) while the experimental group consisted of 24 seventh grade students (16 female, 8 male). Socioeconomic status of the students attending the school was similar, with the majority of the students coming from lower to middle-class families. The state primary school was chosen because of the availability of a highly equipped computer laboratory with PCs.

Measures

In this study, the data were collected with the *Mathematics Achievement Test* (MAT), the *Mathematics Attitude Scale* (MAS) and the *Mathematics Grades of Students* (MGS).

The *Mathematics Achievement Test* (MAT) developed by Torun (2009) was employed to measure the achievements of students in terms of their knowledge regarding the surface area and volume of vertical cylinders. MAT covers 25 multiple-choice questions. Questions for MAT were prepared considering the learning areas of Bloom's taxonomy (knowledge, understanding, application) and 2005 Turkish Primary Mathematics Course Curriculum context. During the development of the MAT, the opinions of experts and mathematics' teachers were taken into consideration. The clarity of items and the content validity were ensured by considering the same experts' opinions. As a result of item analysis conducted by Torun (2009), it was found that item discrimination values for MAT were between 0.21 and 0.94, while item difficulty values were between 0.70 and 0.93. In addition, the KR-20 reliability coefficient for MAT was calculated as 0.71. The appropriateness of MAT within the scope of this research regarding the relevant objectives of sub-learning areas in 2005 Turkish Primary Mathematics Course Curriculum was also assessed by an expert in mathematics education and two mathematics teachers. It was determined that MAT would be used as a pre-test and a post-test according to the expert and teachers' views. The KR-20 reliability coefficient calculated for this study was 0.80 and 0.83 for pre-test and post-test MAT respectively. According to Büyüköztürk (2003), the calculated values for MAT were at an acceptable level. Examples of items taken from the MAT are presented in Appendix.

The *Mathematics Attitudes Scale* (MAS) was developed by Baykul (1990) to estimate the students' attitudes toward mathematics. The MAS was composed of 30 items with a 5-point Likert-type scale (1= *strongly disagree*, 5= *strongly agree*), 15 of which were negative items. Baykul (1990) determined that MAS was one-dimensional, which accounted for 56% of the total variance. The Cronbach alpha reliability coefficient was found to be 0.96. In this study, the MAS were distributed to students as pre-test and post-test. The Cronbach alpha reliability coefficient values for pre-and post-tests were calculated as 0.87 and 0.94 respectively. These values indicated that the reliability of the measurements was at an acceptable level.

The *Mathematics Grades of Students* (MGS) includes students' grades for mathematics course in their first term school reports. MGS were obtained from school administration and they range from 1 to 5 points.

Procedure

While selecting 7th grade classes to be the experimental and control groups, mathematics teachers were consulted and MGS were taken into account. Results of the independent sample *t*-test also showed that there was no significant difference between the two groups in terms of the MGS [t (47)=.652, p>.05]. Of these groups, one randomly selected group became the control group while the other became the experimental group. In this study, MAT and MAS were implemented as the pre-test in order to reveal if there was a difference between their attitudes toward mathematics. Firstly, MAS was implemented to prevent the students' attitudes from being influenced by the MAT. The groups were provided with 40 minutes for MAT and 20 minutes for MAS. It was determined that the duration of the tests was sufficient and no problems occurred.

In order to minimize the influences that would be caused by the researchers during the experimental implementation, both groups were instructed by the same teacher. The researchers assumed the role of observers of both groups in the course of implementation and provided solutions for the problems encountered. The teacher who implemented the experiment had been trained for four hours in order to increase his/her level of knowledge regarding CAI, Mebvitamin and Sketchpad materials. In addition, before the very implementation of the experiment, the instructor had offered two hours of instruction about Sketchpad to the students in the experimental group, even if they would use the Sketchpad program only at the most basic level. An outline syllabus was prepared in order to carry out the operations with the experimental and control groups. The implementation lasted for two weeks with four hours each week.

The experimental group was instructed with CAI and utilized the activities developed by the researchers employing Mebvitamin and Sketchpad programs. The experimental group used a computer laboratory for the courses. Necessary measures were taken for each student to use computers actively (operability of computers, checking Internet connections, installing the relevant programs on the computers). Sketchpad and Mebvitamin programs were used as explained below during the implementation:

- Via interactive activities in the Mebvitamin program, students explored surface area and volume connections of vertical circular cylinders. Figure 1 presents a sample activity from Mebvitamin. This activity aimed to make students explore the relationship between the radius of a vertical circular cylinder and its height with the volume of a cylinder.
- Through the activities prepared using Sketchpad program, students solved the problems and during that process they could make connections in relation to the surface area and volume of a vertical circular cylinder actively. Figure 2 presents a snapshot of the screen regarding the activities prepared using the Sketchpad program. In this activity, students saw that it was a rectangle that made up the lateral side of the cylinder. Students used the information that the width of this rectangle is equal to the base circumference of the cylinder, which helped them reach the solution.
- Since CAI materials have a dynamic structure, students experienced an active learning process by trying, finding the information, assuming and testing. Furhermore, CAI materials with dynamic structures allowed students to try, explore and construct their own knowledge. CAI materials also enable students rapid interaction and feedback.

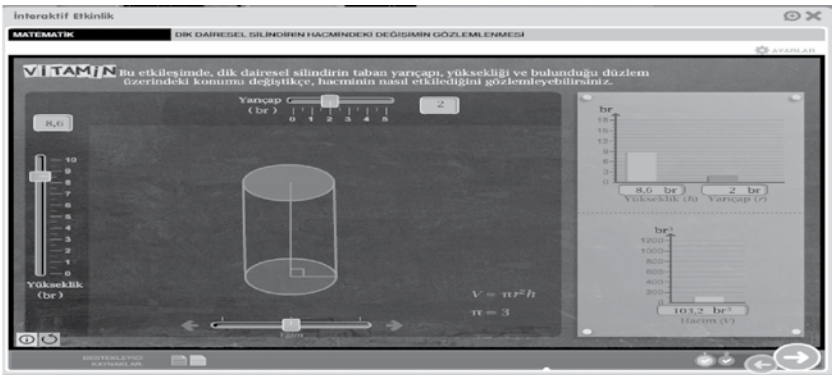

Figure 1. A snapshot of the screen in relation to activities used from Mebvitamin Program

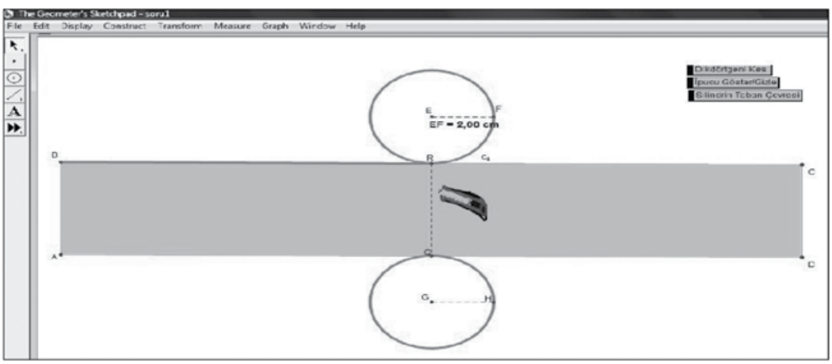

Figure 2. A snapshot of the screen in relation to activities prepared using Sketchpad program

There was no intervention in the control group by any means. They were being taught about surface area and volume of vertical circular cylinders, which means that they received their ordinary instruction. In these lessons, the teacher used the activities in the course book and tried to make students infer the surface area and correlations of volume of vertical circular cylinders. The lessons in this group were generally conducted using questions and answers and direct lectures. However, the students made use of concrete materials (cylinder models, cylinder) in the classroom. The students solved the questions in the course book sometimes in groups and sometimes individually at certain phases of the lesson. The lessons were mainly teacher-centered even though there were some learner-centered activities. Therefore, the instruction which the control group received could be classified as the traditional instruction method.

Data Analysis

In this study, positive items in the MAS were scored ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). For the negative items, the scoring was reversed. Higher scores on the scale indicate more positive attitudes toward mathematics. The correct answers to multiple-choice questions in MAT scored 1 point, while incorrect answers or blank questions scored 0 points. So, the pre-test and post-tests scores for MAT and MAS were obtained for each student. The data obtained from MAT and MAS were analyzed using the SPSS 17.0 program. Pre-test MAT and MAS scores and students' mathematics grades (MGS) were accepted as covariate. Covariance analysis (MANCOVA) was conducted in order to reveal the effect of the experimental process on MAT and MAS post-test scores.

Findings

Descriptive statistics results regarding MAT and MAS pre-test and post-test scores are presented in Table 1. Examining the Skewness, Kurtosis and Kolmogorov-Smirnov test values in relation to MAT and MAS scores in Table 1, it was determined that the values are within the acceptable limits and have normal distribution. Before the experimental process, there was no significant difference between pre-test MAT scores [$t\,(47)=-.445, p>.05$] and pre-test MAS scores [$t\,(47)=.300, p>.05$] of students. Besides, no significant difference was detected between the experimental group (M=3.04, SD=1.23) and control group (M=2.80, SD=1.35) in terms of the MGS. Thus, it was accepted that the groups were equal to each other in terms of their mathematics achievements and attitudes toward mathematics.

Examining the change in MAT and MAS pre-test and post-test scores in Table 1, it was seen that both MAT and MAS scores in the experimental group had increased more than in the control group. In order to reveal whether this increase was due to MGS, MAT or MAS pre-test scores, a multivariate covariance analysis (MANCOVA) was conducted with MGS, MAT and MAS pre-test scores accepted as covariate.

Before conducting MANCOVA analysis, the correlation between the independent variables (gender, MGS, MAT and MAS pre-test scores) and dependent variables (MAT and MAS post-test scores) was examined. The correlations between covariates and dependent variables were presented in Table 2.

Table 1
Descriptive statistics for MAT and MAS scores

Variable	Measure	Group	*n*	*M*	*SD*	Skewness	Kurtosis	KS-Z
Math Achiv. Test (MAT)	Pre-test	Experimental	24	5.83	1.52	0.31	-0.53	1.02
		Control	25	6.04	1.71	-0.65	1.23	0.72
	Post-test	Experimental	24	13.75	2.80	-0.20	-0.61	0.64
		Control	25	10.80	2.75	-0.57	1.14	0.71
Math Attitude Scale (MAS)	Pre-test	Experimental	24	83.70	14.97	0.41	-1.05	0.84
		Control	25	82.32	17.26	-0.92	0.18	0.98
	Post-test	Experimental	24	87.75	14.71	1.11	0.56	1.27
		Control	25	84.92	16.62	-0.58	-0.25	0.71

Table 2
Correlation coefficients between independent and dependent variables

Independent Variable	Dependent Variable	
	MAT Post-test Score	MAS Post-test Score
Gender	.085	.153
MGS	.672**	.404**
MAT Pre-test Score	.479**	.323*
MAS Pre-test Score	.424**	.526**

*$p < .05$ **$p < .01$

As seen in Table 2, the correlation between MAT and MAS pre-test scores of dependent variables was significant while the correlation between gender variable was not significant [for MAT scores $r = .085$, $p>.05$; for MAS scores $r=.153$, $p>.05$]. Therefore, MAT and MAS pre-test scores were included in the study as covariate. As a result of the Levene test conducted regarding the MANCOVA test, it was determined that variances were equated in relation to MAT [F (1-47)=2.207, $p>.05$] and MAS [F(1-47) =.417, $p>.05$] scores. Regarding the assumption of equality of slope, MAT and MAS pre-tests were regarded as independent variables and their interactions were tested through this method. As a result of variance analysis, it was seen that the interactions between MGS*Group [F (1-45)=1.824, $p>.05$], MAT pre-test score*Group [F(1-45)= 3.08, $p>.05$] and MAS pre-test scores*Group [F (1-45)=1.476, $p>.05$] were not significant. In order to detect the multi-colinearity assumption of the covariates (pre-test MAT, pre-test MAS, and MGS), the Variance Inflation Factor (VIF) tests were performed. It was determined that the values of the VIF for these variables were 1.29, 1.20, 1.39, respectively. These results indicated that there was no multi-colinearity among covariates (Green, Salkind, & Akey, 2003). After all the assumptions, the MANCOVA test was carried out and the results were shown in Table 3.

Table 3
MANCOVA results

Effect	Wilks' Lambda	F	df	*p*	Eta square (η^2)
Intercept	.830	4.399	2-43	.018	.170
Covariates					
MGS	.657	11.232	2-43	.000	.343
MAT pre-test	.871	3.176	2-43	.052	.129
MAS pre-test	.346	40.665	2-43	.000	.654
Group membership					
Treatment	.610	13.726	2-43	.000	.390

Wilks' Lambda test results in Table 3 showed that when MGS was under control together with MAT and MAS pre-test scores, the instruction conducted with the experimental and control groups created a significant difference on MAT and MAS post-test scores of the students [Wilks'λ=.610, F(2-43)=13.726, η^2 =.390, p < .01]. In order to reveal which dependent variables created such significant differences, one way analysis of covariance (ANCOVA) was carried out. Modified post-test scores of the groups, ANCOVA and Bonferroni test results are shown in Table 4.

Table 4
Results of ANCOVA for MAT and MAS scores

Variable	Group	*n*	M^a	Std. error (SE)	Mean dif. (I-J)	df	*F*	*p*	Partial η^2
MAT Score	Exp. (I)	24	13.606	.366	2.668	1-44	26.813	.000	.379
	Control (J)	25	10.938	.358					
MAS Score	Exp. (I)	24	87.381	1.801	2.107	1-44	.690	.441	.015
	Control (J)	25	85.274	1.764					

[a]Estimated marginal means for post-test

As seen in Table 4, when pre-test scores of groups related to MGS, MAT and MAS were controlled, ANCOVA results showed that there was a significant difference between the modified MAT post-test scores of the experimental and control group [F(1-44)=26.813, η^2 =.379, p<.01]. Regarding the MAT score in Table 4, students in the experimental group benefited (M=13.606) significantly more than those from the control group (M=0.938) [*Mean difference* = 2.668, p< .01]. If the effect size (partial eta squared = .379) for MAT scores should be evaluated according to Cohen (1988), it can be stated that CAI had a great impact on students' mathematics achievements in the experimental group.

MGS, MAT and MAS pre-test scores of groups were controlled for MAS post-test analysis. As seen in Table 4, modified MAS post-test scores of students in the experimental group (M=87.381) are higher compared to those of the control group (M=85.274). However, ANCOVA results indicated that there was no significant difference between the modified MAS post-test scores of the experimental group taught with CAI and the control group taught in the traditional way [$F(1\text{-}44)=.690$, $\eta^2=.015$, $p>.05$]. This finding showed that two types of instruction implemented in the experimental group and the control group did not make a significant difference in students' attitudes toward mathematics.

Discussion and Conclusion

This study aimed to determine the effect of computer assisted instruction (CAI) on 7th grade students' achievements and attitudes toward mathematics in relation to learning the concept of surface area and volume of vertical circular cylinders. The results of this study showed that there was a significant difference in the experimental group in relation to their mathematics achievement. Moreover, the effect size (η^2 =.379) for MAT scores showed that the experimental process has a great influence on students' mathematics achievement. These findings proved that CAI is more effective in increasing mathematics achievements of students compared to traditional methods. These results correspond with other results of studies conducted in recent years in relation to teaching mathematics at different grades (Baki et al., 2011; Barkatsas et al., 2009; Bedir, 2005; Birgin et al., 2008; Helvacı, 2010; Gürbüz & Birgin, 2012; Işıksal & Aşkar, 2005; Lio, 2007; Özdemir et al., 2010; Pilli & Aksu, 2013; Qing & Xin, 2010; Seo & Bryant, 2009; Tutak & Birgin, 2008; Ubuz et al., 2009; Yeşilyurt, 2010; Yıldız, 2009). Similarly, the results of various studies conducted at the secondary school level showed that CAI is more successful than traditional methods in teaching "*coordinates of a point on a plane, symmetry and straight line graphics*" (Işıksal & Aşkar, 2005), "*transformation geometry and surface areas of rectangular areas*" (Özdemir et al., 2010), "*circle, closed circle and cylinder*" (Tabuk, 2003), "*angles and triangles*" (Bedir, 2005), "*polygons*" (Erbas & Yenmez, 2011), and "*geometric objects*" (Hangül & Üzel, 2010). In this respect, it is possible to say that they support the findings of this study.

In this study, CAI materials using dynamic software programs have important impacts on the mathematic achievements of students, increasing the performance of the experimental group significantly. That is because CAI materials with dynamic structures used within the scope of the research allowed students to try, explore and construct their own knowledge. Furthermore, dynamic software improved the thinking skills of students with rapid interaction and feedbacks, which led them to internalize the information quickly. As a matter of fact, in a study with seventh grade students, Ubuz et al., (2009) found that students taught via the dynamic software programs (*Geometer's Sketchpad)* had significantly better performance regarding the learning of line, angle and polygon concepts than those students taught in the traditional way. Comparing CAI to traditional methods, Bedir (2005) also determined that CAI increased students' mathematics achievements when Geometer's Sketchpad software was used while teaching "*angles and triangles*" at the primary school seventh grade level. Similarly, Baki et al. (2011), Birgin et al. (2008), Erbas and Yenmez (2011), and Işıksal and Aşkar (2005) emphasized that dynamic geometry software contributed to students' achievement and comprehension of geometry. On the other hand, Takunyacı (2007) compared CAI and the traditional method by employing an experimental method to teach "surface areas and volumes" unit using software developed by a private company. However, the results of this study showed that there was no significant difference between CAI and traditional methods in terms of students' achievements. The researcher interpreted this result with the assumption that instructional software used for CAI was not dynamic, effective and efficient.

On the other hand, the results of this study showed that there was no significant difference between the experimental group instructed with CAI and the control group instructed traditionally in terms of post-test MAS score. This result is parallel with the result obtained by Arslan (2008). Nevertheless, this result contradicts the results of many previous studies (Aktümen & Kaçar, 2008; Aliasgari, Riahinia, & Mojdehavar, 2010; Baki & Çakıroğlu, 2011; Baki & Güveli, 2008; Barkatsas et al., 2009; Bedir, 2005; Duru et al., 2012; Gürbüz et al., 2009; Güven, 2002; Hangül & Üzel, 2010; Helvacı, 2010; Lopez-Morteo & Lopez, 2007; Pilli & Aksu, 2013; Santally et al., 2004; Yıldız, 2009) advocating that CAI positively affects the mathematics attitudes of students. For example, Hangül and Üzel (2010) concluded that CAI creates more positive attitudes toward mathematics than traditional methods in teaching "*geometric objects*" at the eighth grade level. Baki & Güveli (2008) also reached the conclusion that computer assisted material use has a positive effect on students' attitudes toward mathematics. Owing to a meta-analysis conducted by Santally et al. (2004), it was revealed that CAI increases motivation to learn mathematics and improves attitudes toward mathematics.

It is thought that a short-term experimental process (2 weeks) in this study is a relatively important factor in not being able to create a significant difference in the students' attitudes toward mathematics. Indeed, some of the results of studies conducted at different period of time and disciplines supported the assumption that it is difficult to change the cognitive characteristics of individuals such as attitude, interest, and level of concern in a short period of time (Gönen, Kocakaya, & İnan, 2006). However, long-term CAI implementations (Baki & Çakıroğlu, 2011; Birgin et al., 2010; Erbaş & Yenmez, 2011; Güven, 2002; Helvacı, 2010; Pilli & Aksu, 2013; Seo & Bryant, 2009; Ubuz et al., 2009; Yıldız, 2009) have proved to be positively influential on students' attitudes and views toward mathematics and geometry.

Another reason why a significant difference was not created in the attitudes of students toward mathematics as a result of the experimental process may be that the students in the experimental group may have had negative attitudes toward computer technologies. Previous studies revealed that students who are inexperienced in using computers are not eager to use them (Aşkar & Umay, 2001; Birgin et al., 2009). Computer experience levels of students were not checked before the implementation in this study. Due to the fact that the primary school where the research was conducted is located in a suburban area, and the fact that teachers said many of the students are in poor socioeconomic situations, we may conclude that the examinees do not have the required level of experience to correctly utilize the computer technologies. Considered from this aspect, it may be possible that the experimental group students with a low level of computer experience have negative attitudes toward computer-assisted learning, which negatively affected their mathematics attitudes.

In brief, this research revealed that CAI created a significant difference in increasing the mathematics achievements of 7th grade students in relation to the topic of surface area and volume of vertical circular cylinder, while it did not make a significant difference in their attitudes toward mathematics. Recommendations regarding the results, experimental implementation and limitations of this research are as follows:

This research proved that computer assisted instruction contributed to the mathematics achievements of learners. Thus, it would be useful to examine the effect of CAI with appropriate mathematical activities for different topics and other grades.

The effect of the experimental implementation on students' achievement was determined only by pre-test/post-test scores within the scope of this research. Hence, it may be said that this study is limited in terms of examining the effect of CAI on permanent learning. Therefore, future studies may deal with this aspect.

Unlike many other studies, two-week CAI implementation did not create a significant difference in students' attitudes toward mathematics, compared to traditional methods. This may be the result of short-term nature of our CAI implementation experiment. Considered from this aspect, it would be worthwhile to study the effect of longer term CAI implementation on students' attitudes toward mathematics.

Since students' computer usage skills in the experimental group were not controlled in this research, it was not possible to test whether this influenced their attitudes toward mathematics negatively or not. Therefore, it would be useful to test whether controlling this factor when studying the effect of CAI on students' attitudes would provide more robust results.

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Appendix *Some questions in the MAT*

Fig. (a)

Q5) If Ali wants to calculate the total area of the tin given in *Fig.* (a), which information must he have?

A) Side length of the lateral surface and Radius of the cylinder
B) Perimeter of the base
C) Lateral area
D) Height and side length of lateral surface

Q7) If the base radius of a right cylinder is increased by four times and its height is decreased by half, how will the volume of the cylinder change?

A) Increase by 8 times B) Increase by 4 times C) Increase by 2 times D) Not change

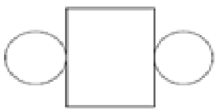

Fig. (b)

Q21) The lateral face of the cylinder is given, whose open form is given in *Fig.* (b). It is a square and the perimeter of the square is 96cm. So, what is the total area of the cylinder?

A) 96 B) 158 C) 478 D) 672

Q23) The length of an iron pipe with inner Radius 6cm and outer Radius 10cm is 18cm. If this iron pipe is immersed in a pot which is full of water, how many cm^3 of water will pour out of this pot? (π=3)

A) 954 B) 864 C) 800 D) 740

Utjecaj nastave uz pomoć računala na postignuća i stavove učenika sedmog razreda prema matematici: slučaj obrade teme „Uspravni kružni valjak"

Sažetak

Cilj je ovoga rada ispitati učinak nastave uz pomoć računala na postignuća i stavove učenika sedmog razreda prema matematici kada se radi o pojmovima kao što su „oplošje i obujam uspravnog kružnog valjka". Korišten je kvazieksperimentalan dizajn istraživanja koji je uključivao kontrolnu skupinu na kojoj je proveden predtest i posttest. Istraživanje je provedeno na uzorku od 49 učenika sedmog razreda u Turskoj (24 učenika u eksperimentalnoj skupini i 25 učenika u kontrolnoj skupini). Učenike u eksperimentalnoj skupini poučavalo se uz pomoć računala, a učenici u kontrolnoj skupini poučavani su na tradicionalan način (izravna nastava koja se temelji na udžbenicima). Na obje skupine proveden je „Test postignuća iz matematike" i „Ljestvica za ispitivanje stavova prema matematici", kao predtest i posttest. Podaci su analizirani multivarijatnom analizom varijance (MANCOVA). Rezultati upućuju na to da nastava uz pomoć računala značajno poboljšava postignuća učenika u matematici u usporedbi s rezultatima dobivenima provedbom tradicionalnog načina nastave. Međutim, pokazalo se da kratkotrajna primjena nastave uz pomoć računala nije značajno promijenila stavove učenika prema matematici.

Ključne riječi: *matematičko obrazovanje; nastava uz pomoć računala; postignuća u matematici; stavovi prema matematici; učenik sedmog razreda.*

Uvod

U posljednja dva desetljeća svjedočimo nevjerojatnim promjenama u ulozi tehnologije u nastavi matematike. Takve promjene posebno su vidljive u izvještajimaa Nacionalnog vijeća nastavnika matematike. U izvještaju *Profesionalni standardi u nastavi matematike* (NTCM, 1991) kalkulatori i računala smatraju se instrumentima koji se trebaju koristiti da bi poboljšali matematičku komunikaciju i razmišljanje kod učenika. U dokumentu *Principi i standardi školske matematike* (NTCM, 2000) također se navodi da pravilna upotreba tehnologije u nastavi matematike pruža učenicima praktično i aktivno iskustvo učenja, što im ujedno omogućuje bolje razumijevanje i konkretno učenje. K tome, *Turski osnovnoškolski kurikul za matematiku*, koji se počeo provoditi 2005. godine, ističe potrebu djelotvornog korištenja tehnologije u učenju i nastavi matematike (MoNE, 2005). U ovom kontekstu tursko Ministarstvo nacionalnog obrazovanja (MoNE) ima za cilj opremiti svih 40.000 škola i 620.000 učionica tehnološkim pomagalima (tablet računalima, računalima, pametnim pločama, projektorima, Internet priključkom itd.) do 2023. godine (Işıklı, Bozkurt i Birgin, 2012).

Računala nisu korisna samo zbog svojih karakteristika računanja nego i zbog mogućnosti da na ekranima učine apstraktne pojmove konkretnima i da olakšaju proces učenja (Baki, 2001). Zapravo, mnoga su novija istraživanja dokazala da nastava uz pomoć računala ima pozitivan utjecaj na učenje i postignuća učenika kada se radi o matematičkim pojmovima (Baki, Kösa i Güven, 2011; Baki i Çakıroğlu, 2011; Barkatsas, Kasimatis i Gialamas, 2009; Birgin i sur., 2008; Erbas i Yenmez, 2011; Gürbüz i Birgin, 2012; Işıksal i Aşkar, 2005; Özdemir, Tektaş i Egelioğlu, 2010; Pilli i Aksu, 2013; Tabuk, 2003; Tjaden i Martin, 1995; Tutak i Birgin, 2008; Ubuz, Ustun i Erbas, 2009; Qing i Xin, 2010; Yıldız, 2009). Işıksal i Aşkar (2005) istraživali su učinak nastave uz pomoć računala koja se sastojala od upotrebe Excela i računalnog programa za dinamičnu geometriju (Autograph) te ga usporedili s tradicionalnom nastavom. Tema je bila „koordinate točke u ravnini, simetrija i graf linearne funkcije". Rezultati istraživanja pokazali su da su matematička postignuća skupine s kojom se provodila nastava uz pomoć računalnog programa za dinamičnu geometriju bila znatno bolja od postignuća skupine koju se podučavalo na tradicionalan način i s Excel računalnim programom. Özdemir i sur. (2010) došli su do spoznaje da je obrada tema *transformacijska geometrija* i *površine tetragonskih ploha* u sedmom razredu uz pomoć računala puno učinkovitija od tradicionalne nastave. Slično tome, postignut je konsenzus da je na osnovnoškolskoj razini nastava uz pomoć računala uspješnija od tradicionalnih metoda kada se obrađuju teme kao što su „graf linearne funkcije" (Birgin i sur., 2008), „krug, kružni isječak i valjak" (Tabuk, 2003), „kutovi i pravokutnici" (Bedir, 2005) i „mnogokuti" (Erbas i Yenmez, 2011). Qing i Xin (2010) proveli su metaanalizu različitih istraživanja o nastavi uz pomoć računala koja se provodila od vrtićke dobi do dvanaestog razreda. Rezultati su pokazali da nastava uz pomoć računala ima pozitivan utjecaj na matematička postignuća učenika. Yeşilyurt (2000) je također proveo metaanalizu istraživanja provedenih u razdoblju između 2000. i 2008. godine o nastavi uz pomoć računala u području prirodnih znanosti i matematike. Rezultati su također pokazali da nastava uz pomoć računala ima pozitivan utjecaj na postignuća učenika.

Isto tako, mnoga istraživanja koja su se bavila utjecajem nastave uz pomoć računala na stavove učenika prema matematici pokazala su da računalna tehnologija pozitivno utječe na stavove učenika (Aktümen i Kaçar, 2008; Aliasgari, Riahinia i Mojdehavar, 2010; Baki i Güveli 2008; Barkatsas i sur., 2009; Bedir, 2005; Duru, Peker i Birgin, 2012; Funkhouser, 2002; Gürbüz, Çatlıoğlu, Birgin i Toprak, 2009; Güven, 2002; Hangül i Üzel, 2010; Işıksal i Aşkar, 2005; Köklü i Topçu, 2012; Lopez-Morteo i Lopez, 2007; Pilli i Aksu, 2013; Seo i Bryant, 2009; Yıldız, 2009). U tom kontekstu, Hangül i Üzel (2010) došli su do spoznaje da je nastava uz pomoć računala poboljšala stavove učenika osmog razreda prema matematici u usporedbi s tradicionalnom nastavom pri obradi teme „geometrijska tijela". Baki i Güveli (2008) su utvrdili da upotreba nastavnih materijala uz pomoć računala ima pozitivan utjecaj na stavove učenika prema matematici. Güven (2002) je također došao do tog zaključka koristeći se Cabrijem, računalnim programom za dinamičnu geometriju, obrađujući teme iz geometrije tijekom nastave matematike u sedmom razredu. Njegovi rezultati pokazuju da je nastava uz pomoć računala pozitivno utjecala na razumijevanje geometrije kod učenika. Slično tome, istraživanje koje su proveli Akinsola i Animasahun (2007) u srednjoj školi pokazalo je da je nastava uz pomoć računala utemeljena na okruženju simulacije i igre kod skupine koja je iskusila takvu nastavu stvorila pozitivnije stavove prema matematici nego što su ih imali učenici u skupini u kojoj se nastava provodila na tradicionalan način. U metaanalizi koju su proveli Santally, Boojawon i Senteni (2004) pokazalo se da nastava uz pomoć računala podiže razinu motivacije učenika za učenje matematike i doprinosi razvoju njihova pozitivnog stava prema matematici.

Neka istraživanja su pokazala da mnogi učenici turskih osnovnih i srednjih škola imaju strah od geometrije i da je općenito ne vole. Štoviše, turski učenici koji su sudjelovali u Nacionalnom istraživanju o trendovima u matematici i prirodnim znanostima (TIMSS) provedenom u razdoblju između 1999. i 2007. godine pokazali su prosječna postignuća koja su bila ispod međunarodnog prosjeka. Turski učenici bili su 34. od 38 zemalja u području učenja geometrije, prema podacima Nacionalnog istraživanja o trendovima u matematici i prirodnim znanostima 1999. godine (MoNE, 2003), a 2007. godine bili su 46. od 56 zemalja (MoNE, 2011). Osim toga, kada se pogledaju postignuća turskih učenika u području razumijevanja geometrije u rezultatima istraživanja od 1997. i 2007. godine, može se vidjeti značajan pad od 7 mjesta 2007. godine. Ti rezultati pokazali su da turski učenici imaju velikih teškoća u učenju geometrije.

U nastavi geometrije učenici uče o karakterističnim obilježjima geometrijskih likova i tijela i vezama između njih. Prostorna vizualizacija – zamišljanje dviju ili triju dimenzija geometrijskog lika u prostoru – i sagledavanje različitih aspekata najvažniji su dijelovi geometrijskog razmišljanja (NCTM, 2000). Izraz „računalni program za dinamičnu geometriju" zajednički je naziv za različite vrste takvih računalnih programa koji su osmišljeni za Geometer's Sketchpad, Cabri Geometry, Cinderella i GeoCebra. Računalni programi za dinamičnu geometriju pomogli su učenicima da stvore pretpostavke, istražuju teoreme i veze i testiraju ih tako što geometriju pomiču od statičnog papira i olovke, te je čine dinamičnom na ekranu računala (Güven i

Karataş, 2003). Izvještaji *Nacionalnog vijeća nastavnika matematike* (2000) i *Novog turskog osnovnoškolskog kurikula za matematiku* također navode da su konkretni materijali, crteži i računalni programi za dinamičnu geometriju neophodni da bi se geometrija mogla naučiti (MoNE, 2005). Računalni programi za dinamičnu geometriju (npr. Geometer's Sketchpad, Cabri, Cinderella ili GeoCebra) pomažu učenicima u procesu uspostavljanja veza između geometrijskih likova i stvaranja zaključaka.

Računalni programi za dinamičnu geometriju potencijalno su jaki alati za učenike pri učenju pojmova iz geometrije na dinamičan i aktivan način. S takvim programima mogu se istražiti svojstva geometrijskih likova i veze između likova u dvodimenzionalnom prostoru (Keşan i Çalışkan, 2013). Interaktivna dvodimenzionalna i trodimenzionalna grafika ugrađena u geometrijske računalne programe također omogućuje učenicima vizualno istraživanje svojstava geometrijskih likova i pomaže im u razumijevanju geometrijskih veza (Sea i Woo, 2010; Steen, Brooks i Lyon, 2006). Istraživanja su također pokazala da je računalni program za geometriju djelotvoran jer ima dinamična svojstva i pruža učenicima priliku da se koncentriraju na puno apstraktnije strukture od onih koje se uobičajeno koriste na papiru (Baki, Kösa i Güven, 2011; Erbas i Yenmez, 2011; Hazan i Goldenberg, 1997; Işıksal i Aşkar, 2005; Tutak i Birgin, 2008; Yıldız, 2009). Na taj se način kod učenika povećava moć zamišljanja i oni će biti sposobni analizirati, stvarati pretpostavke i generalizirati. Takva situacija će kod učenika izravno razviti vještine rješavanja problema (Baki, 2002). Kod takvog novog pristupa učenici imaju priliku istraživati, stvarati pretpostavke, testirati ih i odbaciti, oblikovati i objasniti različite aspekte, jer mogu lako ući u istraživačko okruženje (Güven i Karataş, 2003). Korištenjem računalnih programa za dinamičnu geometriju u nastavi učenici mogu izrađivati geometrijske crteže ili provoditi interaktivna istraživanja oblicima dinamične geometrije koje su pripremili nastavnici (MoNE, 2005).

Ovo istraživanje usredotočeno je na nastavnu temu iz matematike koja se obrađuje u sedmom razredu – „površina i obujam uspravnog kružnog valjka". Ta je tema također dobra osnova za sljedeću temu, „površina i obujam geometrijskih tijela", koja se, prema *Turskom kurikulu za matematiku,* obrađuje u osmom razredu. Te su teme iznimne zbog svoje trodimenzionalnosti. Smatra se da je primjena računalne tehnologije više nego korisna u ovom slučaju zbog vizualnosti i mogućnosti istraživanja, a koje učenicima pružaju opsežno učenje. Kako je materijal trodimenzionalan, bilo bi korisno ispitati utjecaj računalne tehnologije pri obradi tema kao što su površina i obujam uspravnog kružnog valjka na stavove i postignuća učenika. Cilj je ovog istraživanja utvrditi utjecaj korištenja računalne tehnologije u obradi nastavnih tema kao što su površina i obujam uspravnog kružnog valjka na postignuća učenika sedmog razreda i na njihove stavove prema matematici. Vodeći o tome računa, pokušali smo odgovoriti na sljedeća pitanja:

a) Postoji li značajna razlika između rezultata na testovima postignuća kod učenika koje se podučavalo uz pomoć računala u usporedbi s učenicima koji su bili podučavani samo uz pomoć udžbenika?

b) Postoji li značajna razlika između rezultata na Ljestvici za ispitivanje stavova prema matematici kod učenika koje se podučavalo uz pomoć računala u usporedbi s onim učenicima koji su bili podučavani samo uz pomoć udžbenika?

Metode

U ovom istraživanju koristili smo se kvazieksperimentalnim modelom s predtestom i posttestom. Kvazieksperimentalni modeli općenito se više koriste onda kada se učenike ne može nasumično rasporediti u eskperimentalnu i kontrolnu skupinu (Çepni, 2008). Stoga smo odabrali skupine među učenicima sedmog razreda u državnoj osnovnoj školi u kojoj smo odlučili provesti istraživanje. Zadržano je prirodno razredno okruženje jer se nasumično raspoređivanje učenika nije moglo provesti zbog sadašnje strukture škole. Jedna od skupina koju smo nasumično odabrali određena je za kontrolnu skupinu, a druga za eksperimentalnu. S eksperimentalnom skupinom provodila se nastava uz pomoć računala, a kod kontrolne skupine nije bilo promjena, nego se nastavilo s tradicionalnom nastavom (izravna nastava uz pomoć udžbenika). Kvazieksperimentalno istraživanje provodilo se u drugom polugodištu školske godine 2010./2011.

Sudionici

Uzorak sudionika u istraživanju sastojao se od 49 učenika sedmog razreda državne osnovne škole u predgrađu Uşaka u Turskoj. Kontrolna skupina sastojala se od 25 učenika sedmog razreda (14 djevojaka i 11 mladića), a eksperimentalna od 24 učenika sedmog razreda (16 djevojaka i 8 mladića). Socioekonomski status učenika koji pohađaju školu bio je sličan. Većina učenika dolaze iz obitelji niže do srednje klase. Odabrana je državna osnovna škola zbog dostupnosti izvrsno opremljenog računalnog laboratorija s računalima.

Mjerenja

U ovom istraživanju podaci su prikupljeni putem *Testa postignuća iz matematike, Ljestvice za ispitivanje stavova prema matematici* i *Učeničkih ocjena iz matematike*.

Korišten je *Test postignuća iz matematike* koji je razvio Torun (2009) da bi se izmjerila postignuća učenika vezana uz njihovo znanje o površini i obujmu uspravnog valjka. Test postignuća iz matematike sastoji se od 25 pitanja višestrukog izbora. Pitanja su pripremljena u skladu s područjima učenja prema Bloomovoj taksonomiji (znanje, razumijevanje, primjena) i u skladu s kontekstom *Turskoga osnovnoškolskog kurikula za matematiku* iz 2005. Tijekom razvoja testa postignuća iz matematike u obzir su uzeta mišljenja stručnjaka i natavnika matematike. Jasnoća tvrdnji i valjanost sadržaja postignuta je također u dogovoru s istim stručnjacima. Kao rezultat analize tvrdnji koju je proveo Torun (2009) pokazalo se da su diskriminacijske vrijednosti tvrdnji za test postignuća iz matematike bile između 0,21 i 0,94, a vrijednosti težine tvrdnji bile su između 0,70 i 0,93. K tome, koeficijent pouzdanosti KR-20 za test postignuća iz matematike bio je 0,71. Primjerenost testa postignuća iz matematike u sklopu ovog istraživanja, a u vezi s relevantnim ciljevima učenja u *Turskom osnovnoškolskom kurikulu za matematiku* iz 2005. godine procijenili su stručnjak iz obrazovanja u području matematike i dva nastavnika matematike. Dogovoreno je da će se test postignuća iz matematike koristiti kao predtest i posttest, prema mišljenju stručnjaka i nastavnika. Koeficijent pouzdanosti KR-20 izračunat za ovo istraživanje bio je 0,80 i 0,83 pojedinačno za predtest i posttest testa postignuća iz matematike. Prema Büyüköztürku (2003), izračunate vrijednosti za test postignuća iz matematike bile se na prihvatljivoj razini. Primjeri tvrdnji uzeti iz testa postignuća iz matematike prikazani su u Dodatku 1.

Ljestvicu za ispitivanje stavova prema matematici izradio je Baykul (1990) da bi procijenio stavove učenika prema matematici. Ljestvica za ispitivanje stavova prema matematici sastojala se od 30 tvrdnji sa skalom Likertova tipa od 5 stupnjeva (1 = uopće se ne slažem, 5 = u potpunosti se slažem), od kojih je 15 tvrdnji bilo negativno. Baykul (1990) je odredio da je Ljestvica za ispitivanje stavova prema matematici jednodimenzionalna, što određuje 56% ukupne varijance. Cronbach alfa koeficijent pouzdanosti bio je 0,96. U sklopu istraživanja Ljestvica za ispitivanje stavova prema matematici bila je podijeljena učenicima kao predtest i posttest. Vrijednosti Cronbach alfa koeficijenta pouzdanosti za predtest i posttest izračunate su kao 0,87 i 0,94, za svaki posebno. Te vrijednosti pokazale su da je pouzdanost mjerenja na prihvatljivoj razini.

Učeničke ocjene iz matematike. Učeničke ocjene iz matematike obuhvaćaju zaključne ocjene učenika iz matematike za prvo polugodište, a kreću se u rasponu od 1 do 5. Ocjene su dobivene od rukovodeće strukture škole.

Postupak

Pri podjeli razrednih odjela sedmih razreda u eksperimentalnu i kontrolnu skupinu konzultirali smo se s nastavnicima matematike i uzeli u obzir učeničke ocjene iz matematike. Rezultati nezavisnog uzorka t-testa također su pokazali da ne postoji značajna razlika između dvije skupine što se tiče učeničkih ocjena iz matematike [t (47) = ,652, p > ,05]. Od te dvije skupine jedna je nasumično odabrana skupina postala kontrolna skupina, a druga eksperimentalna skupina. U istraživanju su test postignuća iz matematike i Ljestvica za ispitivanje stavova prema matematici primijenjeni u obliku predtesta da bi se ispitalo postoji li razlika između stavova učenika prema matematici. Najprije je primijenjena Ljestvica za ispitivanje stavova prema matematici da bi se spriječio utjecaj testa postignuća iz matematike na stavove učenika prema tom predmetu. Skupine su imale 40 minuta za rješavanje testa postignuća iz matematike i 20 minuta za Ljestvicu za ispitivanje stavova prema matematici. Smatrali smo da je vrijeme za rješavanje testova dovoljno dugo i nisu se pojavili nikakvi problemi.

Da bismo sveli utjecaj istraživača tijekom eksperimentalne provedbe na najmanju moguću mjeru, objema skupinama predavao je isti nastavnik. Istraživači su preuzeli uloge promatrača obiju skupina tijekom provedbe nastave pronalazeći u hodu rješenja probleme koji su se javljali. Nastavnik koji je provodio eksperiment prošao je edukaciju od četiri sata da bi povećao svoju razinu znanja o nastavi uz pomoć računala i materijalima u Mebvitaminu i Sketchpadu. K tome, prije same provedbe eksperimenta nastavnik je ponudio dva sata nastave o Sketchpadu učenicima u eksperiementalnoj skupini, čak i ako se oni poslije budu koristili Sketchpad računalnim programom samo na najosnovnijoj razini. Pripremljen je nacrt nastavnog plana i programa da bi se provodile sve aktivnosti s eksperimentalnom i kontrolnom skupinom. Provedba je trajala dva tjedna, a tjedno su održana po četiri nastavna sata.

Eksperimentalna grupa pohađala je nastavu uz pomoć računala i koristila se aktivnostima koje su izradili istraživači s pomoću Mebvitamin i Sketchpad računalnih programa. Eksperimentalna se skupina koristila računalnim laboratorijem tijekom nastave. Poduzete su sve mjere da bi se svaki učenik mogao aktivno koristiti računalom (ispravno stanje računala, provjera internetske veze, instaliranje relevantnih računalnih programa na računala). Sketchpad i Mebvitamin računalni programi su tijekom provedbe nastave korišteni na sljedeći način:

- Kroz interaktivne vježbe u Mebvitamin računalnom programu učenici su istraživali veze između oplošja i obujma uspravnog kružnog valjka. Na Slici 1 može se vidjeti primjer aktivnosti u Mebvitamin računalnom programu. Ta je vježba imala za cilj navesti učenike na ispitivanje veze između polumjera i visine uspravnog kružnog valjka, kao i njihove veze s obujmom tog valjka.
- Kroz vježbe pripremljene u Sketchpad računalnom programu učenici su rješavali probleme i tijekom tog procesa mogli su aktivno pronalaziti veze između pojmova vezanih uz površinu i obujam uspravnog kružnog valjka. Slika 2 prikazuje snimku ekrana s aktivnostima pripremljenima u Sketchpad programu. U ovoj vježbi učenici su vidjeli da je pravokutnik činio pobočje valjka. Učenici su se koristili informacijom da je širina ovog pravokutnika jednaka opsegu baze valjka, što im je pomoglo da dođu do rješenja.
- Budući da materijali za nastavu uz pomoć računala imaju dinamičnu strukturu, učenici su iskusili proces aktivnog učenja tako što su pokušavali pronaći i pronalazili su potrebne podatke, stvarali pretpostavke i testirali ih. Nadalje, materijali za nastavu uz pomoć računala s dinamičnom strukturom omogućili su učenicima da ispitaju, istraže i izgrade svoje vlastito znanje. Materijali za nastavu uz pomoć računala također učenicima omogućuju brzu interakciju i brzu povratnu informaciju.

Slika 1. i 2.

U kontrolnu skupinu nije se interveniralo ni na koji način. Njima se predavalo o površini i obujmu uspravnog kružnog valjka, što znači da je za njih bila održavana uobičajena, tradicionalna nastava. U takvoj nastavi nastavnik se koristio vježbama iz udžbenika i pokušao je navesti učenike da dođu do zaključka o površini i korelacijama s obujmom uspravnog kružnog valjka. Nastava u toj skupini provodila se uobičajeno, pitanjima i odgovorima, i izravnim predavanjem. Međutim, učenici su se na nastavi koristili konkretnim materijalima (modelima valjka, valjcima). Na pitanja u udžbeniku ponekad su odgovarali u skupinama, a ponekad samostalno, ovisno o fazi nastavnog sata. Nastavni sati uglavnom su u središtu imali nastavnika, iako su se provodile i neke vježbe u kojima su učenici imali glavnu ulogu. Stoga možemo reći da bi se nastava koja se provodila s kontrolnom skupinom mogla nazvati tradicionalnom nastavom.

Analiza podataka

U ovom istraživanju bilježile su se pozitivne tvrdnje u Ljestvici za ispitivanje stavova prema matematici, u rasponu od 1 (uopće se ne slažem) do 5 (u potpunosti se slažem). Bilježenje bodova za negativne tvrdnje bilo je obrnuto. Viši rezultat na Ljestvici upućuje na pozitivnije stavove prema matematici. Točni odgovori na pitanja višestrukog izbora na testu postignuća iz matematike dobili su svaki po 1 bod, a netočni ili prazni odgovori donosili su 0 bodova. Dakle, tako su dobiveni rezultati predtesta i posttesta na testu postignuća iz matematike i Ljestvici za ispitivanje stavova prema matematici za svakog učenika pojedinačno. Ti su podaci analizirani SPSS 17.0 programom. Rezultati predtesta za test postignuća iz matematike i za Ljestvicu za ispitivanje stavova prema matematici, kao i učeničke ocjene iz matematike, uzeti su kao kovarijate. Provedena je analiza kovarijance (MANCOVA) da bi se utvrdio utjecaj eksperimentalnog procesa na rezultate testa postignuća iz matematike i rezultate posttesta Ljestvice za ispitivanje stavova prema matematici.

Rezultati

Rezultati deskriptivne statistike vezani uz rezultate predtesta i posttesta testa postignuća iz matematike i Ljestvice za ispitivanje stavova prema matematici prikazani su u Tablici 1. Analizom asimetrije, spljoštenosti i vrijednosti Kolmogorov-Smirnovljeva testa koji se odnose na rezultate testa postignuća iz matematike i Ljestvice za ispitivanje stavova prema matematici u Tablici 1 odlučeno je da su vrijednosti unutar prihvatljivih granica i da imaju normalnu distribuciju. Prije eksperimentalnog procesa nije pronađena značajna razlika između rezultata koje su učenici postigli na predtestu testa postignuća iz matematike [t (47) = -,445, p > ,05] i na predtestu Ljestvice za ispitivanje stavova prema matematici [t (47) = ,300, p > ,05]. Osim toga, nije uočena značajna razlika između eksperimentalne skupine (M = 3,04, SD = 1,23) i kontrolne skupine (M = 2,80, SD = 1,35) što se tiče učeničkih ocjena iz matematike. Stoga je prihvaćeno da su skupine jednake u smislu matematičkih postignuća i stavova prema matematici.

Tablica 1.

Analizom promjena u rezultatima predtestova i posttestova na testu postignuća iz matematike i Ljestvici za ispitivanje stavova prema matematici prikazanih u Tablici 1 uočeno je da su rezultati testa postignuća iz matematike i rezultati Ljestvice za ispitivanje stavova prema matematici znatno porasli u eksperimentalnoj skupini u usporedbi s kontrolnom skupinom. Da bi se utvrdilo jesu li uzrok tom povećanju učeničke ocjene iz matematike ili rezultati predtesta na testu postignuća iz matematike ili na Ljestvici za ispitivanje stavova prema matematici, provedena je multivarijatna analiza kovarijance (MANCOVA), u kojoj su kao kovarijata prihvaćeni rezultati posttesta na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici. Prije provedbe MANCOVA analize ispitana je korelacija između nezavisnih varijabli (spol, učeničke ocjene iz matematike, rezultati predtesta na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici) i zavisnih varijabli (rezultati posttesta na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici). Korelacije između kovarijata i zavisnih varijabli prikazani su u Tablici 2.

Tablica 2.

Kao što se može vidjeti u Tablici 2, korelacija između rezultata predtesta na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici kao zavisnih varijabli bila je značajna, a korelacija sa spolom kao varijablom nije bila značajna [za rezultate testa postignuća iz matematike r = ,085, p > ,05; za rezultate na Ljestvici za ispitivanje stavova prema matematici r = ,153, p > ,05]. Zbog toga su rezultati predtestova na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici uzeti u istraživanju kao kovarijati. Kao rezultat Levenova testa provedenog zbog MANCOVA testa odlučeno je da su varijance izjednačene što se tiče rezultata testa postignuća iz matematike [F (1-47) = 2,207, p >,05] i Ljestvice za ispitivanje stavova prema matematici [F (1-47) = ,417, p > ,05]. Što se tiče pretpostavke o jednakom rasponu varijable, predtestovi testa postignuća iz matematike i Ljestvice za ispitivanje stavova prema matematici uzeti su kao nezavisne varijable, a njihova interakcija testirana je ovom metodom. Rezultat analize varijance pokazao je da interakcije *Skupine učeničkih ocjena iz matematike [F (1-45) = 1,824, p > ,05], *Skupine rezultata predtesta testa postignuća iz matematike [F (1-45) = 3,08, p > ,05] i *Skupine rezultata predtesta na Ljestvici za ispitivanje stavova prema matematici [F (1-45) = 1,476, p>,05] nisu bile značajne. Da bi se otkrila pretpostavka o multikolinearnosti kovarijata (predtest testa postignuća iz matematike, predtest Ljestvice za ispitivanje stavova prema matematici i učeničke ocjene iz matematike), provedeni su testovi faktora inflacije varijance. Utvrđeno je da su vrijednosti faktora inflacije varijance pojedinačno za svaku od navedenih varijabli bile 1,29, 1,20 i 1,39. Ti rezultati upućuju na to da ne postoji multikolinearnost između kovarijata (Green, Salkind i Akey, 2003). Nakon svih navedenih pretpostavki proveden je MANCOVA test čiji su rezultati prikazani u Tablici 3.

Tablica 3.

Rezultati Wilks lambda testa u Tablici 3 pokazuju da kada su učeničke ocjene iz matematike pod kontrolom, uz rezultate predtesta na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici, nastava održana s eksperimentalnom i kontrolnom skupinom značajno je utjecala na rezultate koje su učenici iz tih dviju skupina postigli na posttestu testa postignuća iz matematike i Ljestvici za ispitivanje stavova prema matematici [Wilks'λ = ,610, F (2-43) = 13,726, η^2 = ,390, p < ,01]. Da bi se otkrilo koje su zavisne varijable stvorile takve značajne razlike, provedena je jednosmjerna analiza kovarijance (ANCOVA). Modificirani rezulati posttestova skupina, kao i rezultati ANCOVA i Bonferronijeva testa, prikazani su u Tablici 4.

Tablica 4.

Kako se može vidjeti u Tablici 4, kada su rezultati predtesta obiju skupina vezani uz učeničke ocjene iz matematike, test postignuća iz matematike i Ljestvicu za ispitivanje stavova prema matematici bili kontrolirani, rezultati ANCOVA-e pokazali su da postoji značajna razlika između modificiranih rezultata predtesta na testu postignuća iz matematike kod eksperimentalne i kontrolne skupine [F (1-44)=26,813, η^2 =,379, p < ,01]. Što se tiče rezultata testa postignuća iz matematike prikazanog u Tablici 4, učenici u eksperimentalnoj skupini imali su znatno više koristi (M = 13,606) od učenika u kontrolnoj skupini (M=0,938) [*Srednja razlika* = 2,668, p < ,01]. Ako bi se veličina učinka (parcijalni eta kvadrat=,379) za rezultate testa postignuća iz matematike procjenjivala prema Cohenu (1988), moglo bi se reći da je nastava uz pomoć računala imala velik utjecaj na postignuća iz matematike kod učenika iz eksperimentalne skupine.

Učeničke ocjene iz matematike i rezultati predtestova na testu postignuća iz matematike i na Ljestvici za ispitivanje stavova prema matematici bili su kontrolirani za analizu posttesta na Ljestvici za ispitivanje stavova prema matematici. Kao što se može vidjeti u Tablici 4, modificirani rezultati posttesta na Ljestvici za ispitivanje stavova prema matematici kod učenika iz eksperimentalne skupine (M=87,381) viši su u usporedbi s rezultatima učenika iz kontrolne skupine (M=85,274). Međutim, rezultati ANCOVA-e pokazali su da ne postoji značajna razlika između modificiranih rezultata posttesta na Ljestvici za ispitivanje stavova prema matematici u eksperimentalnoj skupini koja je imala nastavu uz pomoć računala i kontrolnoj skupini koja je imala tradicionalnu nastavu [F (1-44)=,690, η^2 =,015, p >,05]. Taj je rezultat pokazao da dva tipa nastave provedene u eksperimentalnoj i kontrolnoj skupini nisu imala znatan utjecaj na stavove učenika prema matematici.

Rasprava i zaključak

Ovo istraživanje imalo je za cilj odrediti utjecaj nastave uz pomoć računala na postignuća i stavove prema matematici kod učenika sedmog razreda, u vezi s učenjem pojma površine i obujma uspravnog kružnog valjka. Rezultati istraživanja pokazali su da postoji značajna razlika kod eksperimentalne skupine kada se radi o njihovim postignućima iz matematike. Štoviše, veličina učinka (η^2 =,379) rezultata na testu postignuća iz matematike pokazala je da eksperimentalna nastava ima velik utjecaj na postignuća učenika u matematici. Rezultati su dokazali da je nastava uz pomoć računala učinkovitija u poboljšanju postignuća učenika u matematici u usporedbi s tradicionalnim nastavnim metodama. Oni također odgovaraju rezultatima drugih istraživanja koja su provedena u posljednjih nekoliko godina u vezi s nastavom matematike u različitim razredima (Baki i sur., 2011; Barkatsas i sur., 2009; Bedir, 2005; Birgin i sur., 2008; Helvacı, 2010; Gürbüz i Birgin, 2012; Işıksal i Aşkar, 2005; Lio, 2007; Özdemir i sur., 2010; Pilli i Aksu, 2013; Qing i Xin, 2010; Seo i Bryant, 2009; Tutak i Birgin, 2008; Ubuz i sur., 2009; Yeşilyurt, 2010; Yıldız, 2009). Slično tome, rezultati raznih istraživanja provedenih u srednjim školama pokazali su da je nastava uz pomoć računala uspješnija od tradicionalnih nastavnih metoda kada se uče sljedeće teme: *„koordinate točke u ravnini, simetrija i graf linearne funkcije"* (Işıksal i Aşkar, 2005), *„transformacijska geometrija i površina pravokutnika"* (Özdemir i sur., 2010), *„krug, zatvoreni krug i valjak"* (Tabuk, 2003), *„kutovi i trokuti"* (Bedir, 2005), *„mnogokuti"* (Erbas i Yenmez, 2011) i *„geometrijska tijela"* (Hangül i Üzel, 2010). Moguće je reći da su oni u skladu s rezultatima ovog istraživanja.

U ovom istraživanju materijali za nastavu uz pomoć računala koji sadrže dinamične računalne programe imaju važan učinak na postignuća učenika u matematici i značajno podižu praktične sposobnosti učenika iz eksperimentalne skupine. Razlog tome je što materijali za nastavu uz pomoć računala s dinamičnom strukturom, a koji su se koristili u ovom istraživanju, omogućavaju učenicima da iskušaju različita rješenja, istražuju i izgrađuju vlastito znanje. Nadalje, dinamični računalni programi razvili su vještine razmišljanja kod učenika jer pružaju brzu interakciju i povratne informacije, što je učenicima omogućilo brzu internalizaciju informacija. Štoviše, u istraživanju provedenom s učenicima sedmog razreda Ubuz i sur. (2009) saznali su da su učenici koji su imali nastavu uz pomoć dinamičnih računalnih programa (*Geometer's Sketchpad*) puno bolje rješavali zadatke vezane uz pravac, kut i mnogokut nego učenici koji su imali tradicionalnu nastavu. Uspoređujući nastavu uz pomoć računala s tradicionalnim nastavnim metodama, Bedir (2005) je također utvrdio da nastava uz pomoć računala poboljšava postignuća učenika u matematici kada se koristio računalnim programom Geometer's Sketchpad pri obradi teme *„kutovi i trokuti"* u sedmom razredu osnovne škole. Slično tome, Baki (2011), Birgin i sur. (2008), Erbas i Yenmez (2011), Işıksal i Aşkar (2005) naglasili su da su računalni programi za dinamičnu geometriju doprinijeli učeničkim postignućima i razumijevanju geometrije. S druge pak strane, Takunyacı (2007) je usporedio nastavu uz pomoć računala s tradicionalnom nastavom upotrijebivši eksperimentalnu metodu da bi predavao o „površini i obujmu". Koristio se računalnim programom jedne privatne kompanije. Međutim, rezultati tog istraživanja pokazali su da ne postoji značajna razlika u postignućima učenika koji su imali nastavu uz pomoć računala i onih koji su imali tradicionalnu nastavu. Takunyacı je taj rezultat objasnio pretpostavkom da računalni program koji je korišten u nastavi uz pomoć računala nije bio dinamičan i djelotvoran.

Međutim, rezultati ovog istraživanja pokazali su da ne postoji značajna razlika između eskperimentalne skupine koja je imala nastavu uz pomoć računala i kontrolne skupine koja je imala tradicionalnu nastavu što se tiče rezultata posttesta na Ljestvici za ispitivanje stavova prema matematici. Rezultat je jednak rezultatu koji je dobio Arslan (2008). Ipak, proturječan je rezultatima mnogih prijašnjih istraživanja (Aktümen i Kaçar, 2008; Aliasgari, Riahinia i Mojdehavar, 2010; Baki i Çakıroğlu, 2011; Baki i Güveli, 2008; Barkatsas i sur., 2009; Bedir, 2005; Duru i sur., 2012; Gürbüz i sur., 2009; Güven, 2002; Hangül i Üzel, 2010; Helvacı, 2010; Lopez-Morteo i Lopez, 2007; Pilli i Aksu, 2013; Santally i sur., 2004; Yıldız, 2009), pa se tvrdi da nastava uz pomoć računala pozitivno utječe na stavove učenika prema matematici. Na primjer, Hangül i Üzel (2010) su zaključili da nastava uz pomoć računala stvara pozitivnije stavove prema matematici, nego tradicionalne metode kada se obrađuju „*geometrijska tijela*" u osmom razredu. Baki i Güveli (2008) su također došli do zaključka da materijali za nastavu uz pomoć računala imaju pozitivan učinak na stavove učenika prema matematici. Zahvaljujući metaanalizi koju su proveli Santally i sur. (2004) uočeno je da nastava uz pomoć računala podiže stupanj motivacije za učenje matematike i popravlja stav učenika prema matematici.

Smatra se da je kratkotrajni eksperimentalni proces (2 tjedna) u sklopu ovog istraživanja relativno važan faktor u nemogućnosti stvaranja bitnije razlike u stavovima učenika prema matematici. Zaista, neki od rezultata studija provedenih u različito vrijeme i u različitim disciplinama išli su u prilog pretpostavci da je kognitivne karakteristike poput stava, interesa i pažnje pojedinaca teško promijeniti u kratkom vremenu (Gönen, Kocakaya i İnan, 2006). Međutim, dugotrajnija provedba nastave uz pomoć računala (Baki i Çakıroğlu, 2011; Birgin i sur., 2010; Erbaş i Yenmez, 2011; Güven, 2002; Helvacı, 2010; Pilli i Aksu, 2013; Seo i Bryant, 2009; Ubuz i sur., 2009; Yıldız, 2009) pokazala je pozitivan utjecaj na stavove učenika i na njihov pogled na matematiku i geometriju.

Drugi razlog zašto nije nije došlo do značajnije razlike u stavovima učenika prema matematici kao očekivanom rezultatu eksperimentalnog procesa može biti taj što su možda učenici u eksperimentalnoj skupini imali negativan stav prema računalnoj tehnologiji. Prijašnja istraživanja pokazala su da učenici koji nemaju puno iskustva u korištenju računala nisu baš voljni koristiti se računalima (Aşkar i Umay, 2001; Birgin i sur., 2009). Vještine učenika u korištenju računala nisu bile testirane prije provedbe ovog istraživanja. Zbog činjenice da je osnovna škola u kojoj smo proveli istraživanje smještena u predgrađu, kao i zbog činjenice da su sami nastavnici rekli da učenici žive u skromnijim socioekonomskim prilikama, možemo zaključiti da ispitanici nemaju odgovarajuće iskustvo da bi se ispravno koristili računalnom tehnologijom. Gledajući s tog aspekta, moguće je da eksperimentalna skupina s manjim iskustvom korištenja računala ima negativan stav prema nastavi uz pomoć računala, što je negativno utjecalo na njihov stav prema matematici uopće.

Ukratko, ovo istraživanje pokazalo je da je nastava uz pomoć računala dovela do značajne razlike u razvoju postignuća iz matematike kod učenika sedmog razreda kada se radi o temi površine i obujma uspravnog kružnog valjka. Međutim, nije dovela do značajne razlike u stavovima tih istih učenika prema matematici. Preporuke vezane uz takve rezultate, eksperimentalnu provedbu nastave uz pomoć računala i ograničenja ovog istraživanja jesu sljedeće:

- ✓ Ovo istraživanje dokazalo je da nastava uz pomoć računala doprinosi boljim postignućima učenika u matematici. Stoga bi bilo korisno ispitati učinak nastave uz pomoć računala s odgovarajućim matematičkim zadacima za različite teme i različite razrede.
- ✓ U ovom istraživanju utjecaj eksperimentalne provedbe takve nastave na postignuća učenika određen je samo putem rezultata predtesta i posttesta. Dakle, moglo bi se reći da je ovo istraživanje ograničeno u pogledu ispitivanja utjecaja nastave uz pomoć računala na trajno učenje. Stoga bi se buduća istraživanja mogla baviti tim aspektom.
- ✓ Za razliku od mnogih drugih istraživanja, dvotjedna provedba nastave uz pomoć računala nije dovela do značajne razlike u stavovima učenika prema matematici, u usporedbi s tradicionalnim nastavnim metodama. To bi moglo biti rezultat kratkotrajne prirode našeg eksperimenta provedbe nastave uz pomoć računala. Gledajući s tog aspekta, bilo bi dobro proučiti utjecaj dugotrajnije provedbe nastave uz pomoć računala na stavove učenika prema matematici.
- ✓ Kako računalne vještine učenika u eksperimentalnoj skupini nisu kontrolirane u ovom istraživanju, nije bilo moguće testirati je li to imalo negativan utjecaj na njihove stavove prema matematici ili nije. Stoga bi bilo korisno ispitati bi li kontroliranje tog faktora u proučavanju utjecaja nastave uz pomoć računala na stavove učenika dalo jasnije rezultate.