The Enriched Teaching Applications of Geometric Objects Subject with Concrete Models and its Effect on Student Achievements with Computer Assisted Instruction

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***Abstract* – The aim of this study is to reveal the effect of using two different learning environments, namely a "learning environment enriched with concrete models and computer-aided learning environment" and "traditional and computer-aided learning environment" and their effects on students' Geometric Object Subject achievement levels. For this purpose, a mixed research method was used in which qualitative and quantitative research methods were applied together. It was found that the achievement levels of the students were positively affected in both experimental groups, but the students' achievement in geometric objects was higher in the experimental group in which computer-assisted teaching environment and enriched teaching applications were used in combination.**

***Keywords* – Mathematics, geometric objects, concrete models, computer-aided education.**

1. Introduction

When the time and countries are taken into consideration, improvements and advancements in technology have inevitably affected both education systems and student expectations in every country.

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Today, technology and education are two concepts that go hand in hand. This has made it imperative that teachers, who are an important and integral part of the education system, follow the new teaching methods and developments in the field of education and meet the expectations of the students [1]. However, in the subject area, it has been stated, teachers are unable to meet students' expectations, not only in terms of the deficiencies in field knowledge but also in occupational knowledge [2].

Mathematics education acts as a kind of language that helps individuals to understand and express their understanding of the world they live in. Considering our developing world in the light of new technologies, it is necessary to understand mathematics and apply it to daily life problems. As the Ministry of National Education and Culture (MEB) explains, those who know and solve mathematics have more options when preparing themselves for the future [3]. This aspect of mathematics carries a variety of conceptual relationships and facilitates students to develop their reasoning skills and intellectual abilities. In addition, while developing mathematical thinking skills, it allows the development of geometric thinking and spatial thinking skills. When we think of the geometric fields surrounding the individual in the world, the effective use of these fields depends only on understanding them. Therefore, for all the above-mentioned reasons, considering all the fields in mathematics, it can be said that geometry, which is only a sub-branch, has a wide area in education programs [4].

When teaching geometry with new approaches, teachers ask their students to establish the relationship between concepts and representations in their minds. However, in terms of education, it is known that there are cases where this method does not always work. Fyfe, McNeil and Borjas [5] said that learning geometric concepts by students is crucial in mathematics teaching.

It would not be wrong to say that the students may have misconceptions, conceptual errors and lack of knowledge at any level of education that they may encounter due to misleading in mathematics [6].

Given the importance of geometry education, how to prevent problems that may arise during the learning process is extremely important. Considering the problems in geometry education and this situation, pondered is the question of how students' geometry, which is an inseparable sub-branch of mathematics, affects their academic achievements when it is instructed with new approaches. If we look for an answer to this question, it is possible to discuss concrete models that are integral part of mathematics education and CAE, which is an integral component of technology. CAE is the use of computer as a complementary and system-strengthening element in the teaching process, not as an option. It is a teaching method that is formed by using computer technology, which reinforces the teaching process and learning motivation, and is used as an environment in which learning occurs where students can benefit according to their own learning speed.

In other words, the use of computers in the computer-assisted education method during courses enables the student to recognize his/her deficiencies and performance through mutual interaction and to control his/her own learning through feedback graphics, sound, animation and shapes with the help of the course to provide more relevance to the education and training process, which is called CAE [7]. Computer-assisted mathematics teaching (CAMT) is a form of mathematics teaching that uses computer-based cognitive tools in a very specific sense [8].

Concrete models are objects that represent abstract mathematical concepts, such as objects and pictures, and real life objects that can be touched and moved [9],[10]. In teaching practices enriched with concrete models, the students' tendency to see mathematics as an abstract discipline can be eliminated and a type of thinking style that produces answers to real life problems through models can be realized as a dimension of mathematics [4]. Concrete models are also an interdisciplinary concern that covers many other areas in addition to mathematics [11], because the source of modeling problems may be different disciplines other than mathematics [12]. Interdisciplinary problem solving includes the subjects of mathematics, engineering and science, which enable students to overcome real-life problems that they could face now or in the future [13].

In summary, while teaching practices enriched with concrete models are a process, concrete models are the results of repeated processes in which students express their thoughts, make comments, test and organize them [14]. In this respect, the aim of teaching practices enriched with concrete models is to provide the students with a better problem solving skills of mathematical problems, to contribute to the use of critical and creative thinking skills and to improve their attitudes towards mathematics [15],[16].

Thus, the main purpose of this research is to determine the opinions of 4th grade students about the application of teaching enriched with concrete objects and the effect of the CAE on the success of the students while teaching the “Geometric Objects” (GO) subject, which is one of the subjects the Ministry of National Education and Culture has been taken into consideration by the researchers considering the objectives and gains in 4th grade mathematics curriculum.

2. Method

In this study, a mixed method research was used in which quantitative and qualitative approaches were used together. In accordance with the experimental method, an embedded design-experimental model, which is embedded in an experimental design, was used because the aim was to obtain more effective results by using two datasets together [17]. In the process of obtaining quantitative data, one of the experimental research methods, pretest-posttest two experimental group designs GO was implemented for the teaching of the subject. For the Experimental Group 1, the “teaching method enriched with concrete models” and “computer-assisted method” were used, while the Experimental Group 2’s teaching method was “traditional method and computer assisted”. The students' achievements in geometric objects were the dependent variable whose effects were researched. A geometric object test for the GO subject was implemented as both a pretest and a posttest success test on the Experimental Group 1 and the Experimental Group 2. In order to obtain qualitative data, semi-structured interview technic was conducted with the permission of the students regarding the effectiveness of the experimental process and content analysis was applied to the data obtained. Thus, the data obtained from content analysis were tabulated and interpreted using frequency and percentage values. In order for the readers to understand and interpret the findings of the content analysis, similar data should be brought together under the same concepts and themes [18].

The independent variables of the study were “teaching environment enriched with concrete models” and “computer assisted teaching environment”. On the other hand, the dependent variable of the research was the mathematics achievement of the students.

Participants

The study participants were 4th grade students from one of the private schools under the Ministry of National Education in the 2018-2019 academic year. Out of a total of 72 randomly selected 4th grade students from the school, 36 students were randomly assigned to the Experimental Group 1, while 36 students were assigned to the Experimental Group 2 similarly. Information about these groups has been presented in Table 1. Neutral assignment refers to the equality of the probability of being assigned to each of the experimental conditions for a subject before the data collection work commences [19]. In both experimental groups, one of the researchers, who had 15 years of classroom teaching experience, taught the geometric objects subject. The other author acted as an observer during the experimental procedure.

Data Collection

In this research, quantitative data collection tool was used besides qualitative data collection tool to increase the validity of the study and at the same time to triangulate multiple data sets.

Quantitative Data Collection Tool

As a quantitative data collection tool, 20 multiple-choice geometric objects developed by the researchers were used as achievement tests to determine the effect of instructional applications enriched with concrete models and CAE applications on students' achievement in GO. In order to develop the geometry course achievement test, the researchers prepared 25 multiple choice questions within the geometry curriculum by first taking the opinions of two subject area experts and two classroom teachers. After the face validity and content validity of the questionnaire were prepared, it was applied to 120 fifth grade students. A test with 20 questions of medium difficulty measuring the success of geometric objects was developed by eliminating unreliable and excessively difficult questions. The reliability coefficient (KR20) calculated for the developed test was found to be .82. The highest score that can be taken from the test is 100 because each question is formed of 5 aspects. In this case, it can be said that the reliability of the test is good [19]. The geometrical objects success test was applied as a pre-test and post-test in both groups.

Qualitative Data Collection Tool

Since the quantitative research data obtained from the test may not reflect the actual performance of the students, qualitative data were also used to support these data. The student interview form, which was used at the end of the experimental process, was developed by the researchers according to expert opinions and used as a qualitative data collection tool. The interview form was developed after the literature review and was prepared for 4th grade primary school students. During the preparation of the questions, in order to facilitate more effective and efficient communication with the students, the questions were prepared to generate clear, understandable and detailed answers. However, alternative explanatory questions and clues were also considered where the students did not understand the questions [18]. After the interview form was prepared, the questions were presented to two linguists and a pedagogue. In addition, it was shown to two experts who conducted various studies using the interview method; required amendments and alterations were made based upon the views and recommendations of the five subject area experts. Also, a small pilot application was made after the preparation of the form. The pilot application was made with five students and the form was changed based on the opinions and problems identified by the students. Data were transcribed, coded, and interpreted by five different researchers on the basis of the statements of the five students. In this research, the consensus percentage reliability of the two encoders was calculated and found to be 85%, which is an indicator of reliability [20].

During the validity and reliability studies of the study, also a pilot interview was conducted with five students and then the statements of 15 teachers were transcribed, coded, and themes and sub-themes were created and interpreted by two different researchers. In this research, the consensus percentage reliability of the two encoders was calculated and found to be 90.8%, which is considered reliable [20].

As a result of the changes and amendments, the form was finalized. In the form, there are 5 questions related to the motivation, attitudes towards geometry and the achievements in the geometrics course by the students in the experimental process. These questions are as follows:

1) Were there any differences of the Geometric Objects Unit course in terms of students' duties and behaviors? If any, what are they?

2) Were there any differences in the classroom activities of the Geometric Objects Unit course? If any, what are they?

3) Were there any differences in terms of what you learned from the Geometric Objects Unit course? If any, what are they?

4) What was the different point (s) of the assessment activities of the Geometric Objects Unit course?

5) How did you feel in the classroom? (excited, nervous, relaxed, curious, active, etc.).

Procedure

Prior to the application, semi-structured individual interviews applied to the students from primary school at the same time. Also, qualitative data were obtained through focus group interviews, while individual interviews were conducted with teachers. In the first phase of the study, which is the needs analysis phase, five students were interviewed for a total of 15-20 minutes at the end of the instruction in which the students' learning levels about the geometric objects unit were determined. In addition, it was agreed that the students and the two class teachers would be able to explain the geometric objects with concrete models.

In practice, the subject of GO was presented to the Experimental Group 1 with concrete models in accordance with the lesson plan, and the Experimental Group 2 with computer-aided training (Images 1, 2 and 3). The 4th grade GO subject was instructed in accordance with the MEB syllabus considering the objectives and gains of ”drawing a rectangular prism using squared form or isometric paper, drawing the opening of rectangular prism-shaped models by using squared paper and determining the number of cubes in models consisting of identical cubes”. In computer-aided education, the subject of the experts in the field of geometric objects by taking GeoGebra and the Ministry of Education and Culture approved “Bam Mathematics 3” software was applied in the computer laboratory at the school, “Introduction of the Subject” and “Study Questions” presentation and application were presented using the smart board.

For the Experiment Group 1, in which the application was made with concrete models and computer-aided training, the students followed the lecture with the help of a 7-week computer-aided education program, firstly by using the interactive “Bam Mathematics 3” software on the smart board, and then adapted to the subject by doing exercises on their personal computers (three weeks). In addition, by using the GeoGebra software, students were able to learn Geometric objects better (2 weeks). Then, in groups of four, instructional activities enriched with concrete models were applied (2 weeks). The Experimental Group 1 students were asked to construct three-dimensional objects with concrete models using play-dough and wooden rods and assessed both themselves and their group after the activities. For the Experimental Group 2, drawings were made on the whiteboard in the classroom with traditional teaching, followed by a lecture using the computer-aided education and the interactive “Bam Bam Mathematics 3” software from the smart board and then the students adapted to the subject by answering exercises on their personal computers (total 7 weeks). The geometry achievement test was implemented as a pretest and after the application implemented as a posttest in both experimental groups.

After the application, in order to reveal the differences between the applications in both experimental groups and to support the quantitative data, a total of 10 students (5 volunteer students from each experimental group) (S1.1, S1.2, S1.3, S1.4, S1.5 and S2.1, S2.2, S2.3, S2.4, S2.5) were interviewed. The opinions obtained from the semi-structured interview form (5 questions in total) were tabulated by content analysis.

Image 1. Experiment 1 Group - Enriched teaching with Concrete Models-1

Image 2. Experiment 1 Group - Enriched teaching with Concrete Models-2

Image 3. Computer Aided Education Practices Applied to Experiment Groups 1 and 2

Data Analysis

During this research and analysis of sub-problems, frequency, percentage, arithmetic mean, standard deviation, independent group t-test and two-factor repeated measures ANOVA test and content analysis were used.

Qualitative Results of the Research

The two-factor repeated measures ANOVA test was implemented to the data obtained from the success test administered to both experimental groups before and after the experiment in order to show that both experimental groups were initially equivalent in terms of geometry success and which experimental group was more successful in geometric objects after the application (Table 1.).

Table 1. GO subject success test results of experimental groups

	Group	$\bar{X}$	Sd.	N
Pre-test	Experimental 1	34.86	6.706	36
	Experimental 2	33.33	7.270	36
Post-test	Experimental 1	89.58	5.395	36
	Experimental 2	78.05	8.966	36

When the findings were examined, two-factor repeated measures ANOVA test was used to compare whether there was a significant difference between the achievement averages for the GO subject in Experimental Groups 1 and 2. As a result of the findings, in Table 2., it can be understood that the pre-test GO unit achievement test means between Experimental Groups 1 and 2 are very close to each other and the groups are equivalent (similar). At the beginning of the experiment, it is important for the validity and reliability of the research that the groups' Geometric Objects unit success levels are similar.

Considering the result of the test, there was a significant difference between the experimental groups [$F_{(1,70)} = 54.915$, $p < 0.01$, $\eta^2 = 0.440$]. Based on the results of one-way ANOVA test, we can say that the geometric object achievement test scores ($\bar{X} = 89.58$) of the students which were mentioned in the Experimental Group 1 were higher in the post-test than the Experimental Group 2 ($\bar{X} = 78.05$).

In addition, a significant difference was found between the pre-test and post-test GO achievement test scores in the Experimental Group 1 ($t(35) = -71.060$, $p < .01$). Similarly, a significant difference was found between the pre-test and post-test GO achievement test scores in the Experimental Group 2 ($t(35) = -40.358$, $p < .01$). In this case, teaching can be said to be effective in both experimental groups.

Qualitative Findings of the Research

The qualitative findings obtained in the light of the questions posed to the students in this research are given in this section. Table 2. shows the findings of the different aspects of the geometric objects unit course in terms of the tasks and behaviours of the students in both experimental groups.

Table 2. The views of the students in Experimental Groups 1 and 2 about the different aspects of the geometric objects unit course in terms of the tasks and behaviours of the students

Views	Student Codes (N=10)
Yes, there are difference(s).	**S1.1, S2.2, S1.3, S2.4, S1.5**
We used a smart board.	**S2.1, S2.2, S2.5**
We used materials.	**S1.1, S1.4**
We did activities.	**S1.3, S1.4, S2.5**
We were happy to take part in - group activities.	**S1.2, S1.5**
We were enthusiastic and interested while listening to the lesson.	**S1.1, S2.2, S1.3, S1.4, S2.5**
We started to understand mathematics.	**S1.5**

It can be said that the Experimental Group 2 students use only smart boards, they were enthusiastic and listened to the lesson, while the Experimental Group 1 students used materials (concrete models) in addition to these; they were happy to do activities as a group and started to enjoy mathematics (Table 2.).

When Table 3. is examined, it can be concluded that the geometric objects show the results of different aspects of the unit course in terms of in-class activities of the students in both experimental groups.

Table 3. The views of the students in the Experimental Groups 1 and Zone 2 about the different aspects of the geometric objects unit course in terms of classroom activities

Views	Student Codes (N=10)
Yes, it was very different.	**S1.1, S1.2, S1.3, S1.4, S1.5**
Materials were interesting.	**S1.1, S1.5**
The activities made us to understand the subject.	**S2.3, S1.4, S2.5**
Our learning is more permanent.	**S1.1, S1.2, S1.5**

When Table 3. is examined, the students of the Experimental Group 1 stated that the activities were

very different than the classroom activities, the materials were interesting and their learning was more permanent, while the students in the Experimental Group 2 stated that the activities in the computer aided education facilitated a better understanding of the subject.

Table 4. shows the results of the different aspects of the geometric objects unit course in terms of what the students in both experimental groups learned by doing.

Table 4. The views of the students in Experimental Groups 1 and 2 about the different aspects of the geometric objects unit course in terms of what they learned by doing

Views	Student Codes (n=10)
We learned subjects by discovering.	**S1.2, S1.4**
It was nice to have our personal computers.	**S2.2, S2.5**
İt was very enjoyable to do activities in groups.	**S1.1, S1.3, S1.4**
The software, which we used with smart boards and GeoGebra, allows us to learn the subject better.	**S1.2, S2.3, S1.5, S2.4**

When Table 4. is examined, it was stated that the students in the Experimental Group 1 discovered and learned the subjects and the group work was enjoyable. However, the students of the Experimental Group 2 stated that it was very nice to have a personal computer and that the educational software facilitated a better understanding of the subject. Table 5. shows the results of the different aspects of the geometric objects unit course in terms of the assessment activities of the students in both experimental groups.

Table 5. The views of the students in the Experimental Groups 1 and 2 about the different aspects of the geometric objects unit course in terms of assessment activities

Views	Student Codes (N=10)
It was different to assessed by using computer.	**S2.2, S2.3, S2.5**
We assessed both ourselves and our group at the end of each activity.	**S1.1, S1.2, S1.3, S1.4, S1.5**
There was not only a teacher assessment; we assessed our group and ourselves.	**S1.2, S1.5**
Self-assessment increased our interest in mathematics.	**S1.3, S2.4, S2.5**

The experimental group students stated that the assessment was at the end of each activity and that it was not only in the form of a teacher assessment, but it also consisted of a self-assessment and group assessment (Table 5.). The Experimental group 2 students stated that the assessment was different in the computer environment. Both experimental groups stated that the self-assessment increased their interest in mathematics.

Table 6. shows the results of how the students in both experimental groups of the geometric objects unit course felt in the classroom (excited, nervous, relaxed, curious, effective, etc.).

Table 6. Students' views on how the students in both experimental groups of the Geometric Objects Unit course felt in the classroom

Views	Student Codes
Excited	**S1.1, S1.4, S2.1**
Relaxed/Comfortable	**S2.3, S2.4**
Active	**S1.2, S1.3, S1.5**
Curious/Interested	**S1.3, S2.5**

When Table 6. is examined, students in the Experimental Group 1 revealed that they felt excited and active in the classroom, while the Experimental Group 2 students stated that they were relaxed. In addition, students from both experimental groups said they were curious in the classroom.

Discussion

From the obtained results of this research, a significant difference was observed between the GO achievement test post-test results applied to Experiment Groups 1 and 2 students. When the achievement of the "Geometric Objects" subject enriched with concrete objects test scores were examined. It was observed that the students in the Experimental Group 1 had more success than the students in the Experimental Group 2. In this case, it can be said that the geometric objects teaching method using computer - aided education and enriched with concrete models was more effective in increasing student achievement than the use of traditional teaching and computer - aided education. In another study, it was reported that there was an increase in post-test scores after the application of mathematical modeling activities for students in powered/ exponential numbers teaching. In the same study, it was reported that mathematical modeling and students' interest towards mathematics showed positive development [21]. Similarly, when the importance of mathematical modeling activities is

examined in PISA mathematics success, it supports this finding [22].

First of all, from the findings, a significant difference was observed between the GO achievement scores of the Experimental Group 2, before and after the experimental study, in which the course was conducted with traditional teaching and computer assisted education. When the results obtained were analyzed, it was seen that this difference was in favor of the post-test scores. In this case, it was understood that the students in the Experimental Group 2 were more successful in the post-test, and therefore, traditional teaching with computer-assisted education was deemed to be an effective teaching method [4].

Secondly, from the findings, a significant difference was observed between the GO achievement scores of the Experimental Group 1 students, in which the course taught was enriched with concrete models along with instructional applications and computer-aided training. This difference was found to be in favor of the post-test scores. According to Accascina and Rogora (2006), the use of concrete models in teaching geometry is very important and provides a wide range of support that facilitates the learning of geometry. It has been argued that it is important in learning geometry and provides positive support, particularly for groups of students with low academic achievement levels [25]. In parallel with this information, as post-test scores of the students in Experimental Group 2 were found to be more successful in the post-test, it was concluded that presenting the enriched teaching practices with concrete models combined with CAE was effective.

In addition, the views of the students which was mentioned in Experimental Groups 1 and 2 were compared in the semi-structured interview form. While Experimental Group 2 students stated that they only used smart boards and performed activities in the computer environment, Experimental Group 1 students stated that they used additional materials and they were happy to participate in group work. In addition, Experimental group 1 students stated that they learned by discovering, group activities were enjoyable, assessments were in the form group assessment, and they felt excited and active. In addition, the students of Experimental Group 2 stated that they improved their understanding of the subject with computer-aided educational software, that it was very nice to have a personal computer and that they felt comfortable because the assessment was different in the computer environment. Teaching practices enriched with concrete models in mathematics teaching are supported by computer aided education and in fact they form part of STEM (science, technology, engineering, mathematics) education and it is argued that such studies have positive effects on permanent learning in students. Thus, we conclude that are our results are line with those found by [23] and [24].

3. Conclusion

As a result, the use of instructional applications enriched with concrete models in the teaching of geometric objects and processing with computer assisted education increases student achievement better than traditional teaching and computer-assisted education. After the use of concrete models in the classroom environment and the application of computer-aided education and smart board applications in the instruction of the geometric objects, students were happier as the course was more enjoyable. According to classical assessment environments, it was seen that they felt comfortable because the assessment was different via computer.

Recommendations

The fact that there are few studies on the Geometric Objects Unit in the literature shows that more studies should be performed on this subject. Permanent testing can be performed to determine whether students are more successful with the teaching provided with concrete models, which will allow the permanent success of the students to be revealed. Unfortunately, the curriculum is overloaded in the Education System and time is limited, which forces teachers to address important and broad topics as rapidly and as easily as possible. Geometry subjects can be taught to primary school students with concrete models in addition to mathematics lessons at different times. For new generation students who are trying to keep up with the changing and developing world, it is important for teachers to encourage them to use educational software and to use instructional technologies in the classroom environment.

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