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The Effect of Modeling and Computer-Aided Teaching on Astronomy on Some Learning Products of Seventh Class Learners

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Abstract

The primary purpose of this study is to investigate the effect of modeling techniques and computer-aided guidance material on seventh-grade students' academic achievements, creative thinking, and logical thinking skills in Astronomy concepts in the "Solar System and Beyond" unit. This study was carried out with 66 seventh grade secondary school students. This study was carried out with a quasi-structured research design, one of the experimental research methods. This study was carried out in the fall semester of the 2018-2019 academic year. The study used academic success tests, scientific creativity scales, and logical thinking group tests as data collection tools. The experimental group students used the models based on the computer-aided material and modeling techniques developed by the researcher. The control group, on the other hand, only utilized instruction based on the current curriculum. The difference between the two groups is the activities carried out in computer-aided teaching and modeling-supported instruction. The study results reveal that the Academic Achievement, Scientific Creativity, and Logical Thinking Skills of the experimental group students who applied modeling and computer-assisted instruction were significantly higher than those in the control. As a result of the findings obtained in the study, it is recommended to include different science topics and grade levels in future studies.

Keywords: Astronomy, computer - aided teaching, modeling.

Astronomi Konusunda Modelleme ve Bilgisayar Destekli Öğretimin 7. Sınıf Öğrencilerinin Bazı Öğrenme Ürünlerine Etkisi

Öz

Bu çalışmanın temel amacı yedinci sınıf Fen Bilimleri öğretim programında yer alan “Güneş Sistemi ve Ötesi” ünitesindeki Astronomi kavramlarında modelleme tekniği ve bilgisayar destekli rehber materyali kullanılmasının öğrencilerin akademik başarılarına, yaratıcı düşünmelerine ve mantıksal düşünme becerilerine etkisini araştırmaktır. Deneysel araştırma yöntemlerinden yarı-yapılandırılmış araştırma deseniyle yürütülen bu çalışma, Ordu ili Altınordu ilçesinde yer alan bir devlet okulunda öğrenim gören biri deney biri kontrol olmak üzere toplam 66 yedinci sınıf ortaokul öğrencisi ile gerçekleştirilmiştir. Çalışmada veri toplama aracı olarak akademik başarı testi, Bilimsel yaratıcılık ölçeği ve mantıksal düşünme grup testi kullanılmıştır. 2018 – 2019 eğitim-öğretim yılı güz yarıyılında yürütülen bu çalışmada, deney grubunda mevcut öğretim programına dayalı öğretim ile birlikte araştırmacı tarafından ünite kavramlarına yönelik geliştirilen bilgisayar destekli materyal ve modelleme tekniği ile geliştirilen modeller dersler esnasında kullanılırken, Kontrol grubunda ise sadece mevcut öğretim programına dayalı öğretim kullanılmıştır. Çalışmanın sonucunda, Modelleme ve Bilgisayar Destekli Öğretim uygulanan deney grubu öğrencilerinin, Akademik Başarıları, Bilimsel Yaratıcılıkları ve Mantıksal Düşünme Becerileri, kontrol grubunda yer alan öğrencilere göre anlamlı derecede yüksek olduğu tespit edilmiştir. Çalışma da elde edilen bulgular neticesinde, daha sonra yapılması planlanan çalışmalar da farklı fen konularında ve sınıf seviyelerine yer verilmesi önerilmektedir.

Anahtar kelimeler: Astronomi, bilgisayar destekli öğretim, modelleme.

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INTRODUCTION

Education considers the needs and demands of the period it occurs in. Especially since the beginning of this century, there has been a rapid flow of information. For this reason, education should be realized and planned by considering this rapid flow of information (Karakütük, 2012). In our age, it is not enough for individuals to be surrounded by an education system where they can only access scientific information. It is important to use information, transform it into different forms, and improve cognition. Acquisition of various skills is essential in creating cognitively developed individuals. Especially the fact that subjects and concepts contain more complex and in-depth information makes it necessary for individuals to acquire various skills (Altunçekiç et al., 2005; Bakırcı & Kutlu, 2018).

In the process of acquiring skills, the way information is presented to individuals is very important. Our age adopts an understanding that can transform into different forms and ways rather than an understanding in which information is used in only one dimension (Kind & Osborne, 2017). As a result, individuals experience difficulty in learning structurally complex and three-dimensional structures and concepts. High-level skills have great importance in transforming information into different forms and structures, finding alternative ways, and at the same time, discovering one's learning path (Cañas et al., 2017). Thanks to these skills, individuals can gain different perspectives. Creative thinking skills offer appropriate, innovative, and different solutions to the situations that individuals encounter in their mental processes (Yaşar & Aral, 2010). They are skills that individuals should have regardless of whether the environment is formal or informal. The fact that individuals who think about concepts or topics in different ways do not experience difficulties in the learning process is directly related to their creative thinking skills. Creative thinking skills produce new ways of thinking and different thoughts, which is also significant for a science course directly associated with life. As a result, the originality of individuals' products contributes to increasing success and motivation toward the lesson (Bakır & Öztekin, 2014; Ceran, 2010; Zubaidah et al., 2017). For this reason, methods that improve students' motivations and attitudes in developing creative thinking skills are critical. Like creative thinking, logical thinking skills also contribute to individuals' producing different and original solutions (Aksu, 1988).

For this reason, it is essential for individuals to keep up with the times and to improve their metacognitive development. Logical thinking skill enables individuals to think in detail about the situations they encounter during their learning process and to discover their learning methods (Sert Çıbık & Emrahoğlu, 2008). In cases where individuals have difficulties in the learning process, they should not be pessimistic; instead, they should seek solutions within a cause-effect relationship (Karademir, 2013). This is why metacognitive mental practices need to take place. They help individuals' cognitive development in establishing solid relationships between abstract concepts (Kılıç & Sağlam, 2009). Logical thinking skills are directly related to many topics during a science lesson. They contribute to structuring the teaching of abstract concepts such as science. Logical thinking skills offer different solutions to individuals, especially in departments where individuals have difficulty learning science (Aydın & Kaptan, 2014). Individuals with high logical thinking skills have high attitudes and success in science lessons (Çobanoğlu, 2017).

Appropriate methods are fundamental in developing two types of skills. In addition, continuity in planning education programs is essential for developing skills (Yağmur, 2010). In addition to the expectations and needs of students, contemporary methods should be used. With the help of various features of computer-aided education, it aims to develop other skills in addition to creative and logical thinking skills. At the same time, it is thought to develop students' creative and logical thinking processes besides teaching concepts. Computer-aided education includes various software and hardware elements. It contributes to students' information acquisition in different forms in our age, where information changes rapidly (Tekmen, 2006). Individuals face different problems in the transformation of information into different forms and in the interpretation of information. Computer-aided teaching is fundamental in teaching the skills required to solve these problems (Demirer, 2009). Enriching the learning process with computer-aided teaching materials contributes to teaching concepts to individuals (Osu, 2017). Computer-assisted teaching materials develop students' creative thinking skills (Yeşiltaş & Taş, 2021). Students who access different forms of information can reach different results about their learning methods. Individuals need to explore their learning ways and methods in the teaching of subjects and concepts (Gürkan & Dolapçıoğlu, 2020). Creative and logical thinking skills help students to explore their learning methods (Aksu, 1988). Individuals gain various skills not only through computer-aided teaching materials but also through modeling.

A model is defined as the representation of a concept, phenomenon, idea, or process. It can be seen as representing a system or process planned to be designed. The model is directly associated with the process it represents. Modeling is the process in which the model created is experienced (Ergin et al., 2012). Modeling does not have to reflect all the features of the concept to be reflected. The modeled concept is presented in simpler forms. This way, models ease students in teaching complex concepts (Arslan, 2013). During modeling, students continue using old and new information together (Batı, 2014). The modeling process of the target concept is carried out without breaking away from theories, laws, and actual knowledge (Suabada & Basi, 2012). The modeling process is designed so that complex and difficult-to-understand structures and processes are better visualized in students' minds and learning processes are developed in the desired direction (Lesh & Door, 2003). Modeling is an effective method of transferring unobservable situations to students. The teaching of abstract concepts occurs similarly (Thomson & Brother, 2008). When the renewed science teaching program is analyzed, it includes concepts challenging to teach in addition to many abstract and three-dimensional groups. Especially the unit "Solar System and Beyond" is one of these units. It can be seen that students have difficulty understanding the subject, and misconceptions occur (Özkan & Bal, 2017; Ryan & Williams, 2007). It is thought that classical lesson materials are partially insufficient. For this reason, in addition to the renewed astronomy education, materials suitable for our age and students' needs should be used in astronomy education (Plummer, 2008). The materials that individuals use and teaching materials and tools help them find different solutions in the learning process of other subjects and concepts. In such implications, teaching processes and materials based on instructional design models should be used (Brown, 1992). Gagne (1985) gathered the principles of the instructional design model in four items:

- Different types of teaching to be carried out are vital for many learning areas.
- Learning processes on the learner are planned in ways that form learning styles.
- Learners' learning styles are different for each learning.
- Graded learning refers to mental skills, how they are realized, and the contents that make up the teaching.

Instructional design is the development of learning activities on a systematic basis to provide the learning environments that learners need (Şimşek, 2014). The differences in the student's learning styles and the accompanying changes in the field of education bring the instructional design models to an essential point in learning environments' preparation. Using instructional design models provides better-quality learning environments (Siribaddana, 2010). Instructional design models include organizing teaching-learning activities and preparing and planning all materials intended for use in this direction. This study's theoretical and theoretical foundations are the ARCS instructional design method. The first and most important strategy of ARCS is the attention strategy, in which students' curiosity about the lesson is aroused and continued throughout the lesson (Kutu, 2011). At this point, in preparing computer-aided and modeling-supported materials, it is aimed to choose materials that will increase the student's motivation towards the lesson, keep their interest alive, and have a high sense of curiosity.

This study aimed to determine the effects of modeling and computer-aided teaching on seventh-grade students' scientific creativity, logical thinking skills, and academic achievement. In addition, it aims to test the relationship between Scientific Creativity scores, Logical Thinking scores, and Academic Achievement scores of experimental and control group students supported by Computer and Modeling.

METHOD

This section contains general information about the research pattern, the research design, the working group containing the descriptions of the sample included in the study, the way of collecting the data, the means of the data collection, and the analysis of the data obtained.

Research Design

The studies carried out by the researchers are expected to provide in-depth and desirable information. Therefore, research designs should be used on the nature of the studies. This study adopted a quasi-experimental research design, examining changes in students' scientific creativity scores, logical thinking skills, and academic achievement scores. The use of pre-test and post-test research designs in our country is suitable for research because of the structure of schools (Çepni, 2014; Kaya, 2015). At the same time, since it is possible to present an existing situation, survey and causal-comparative research are used as descriptive research methods (Çepni et al., 2010).

Participants

The study sample comprises 66 students studying in a public school in Altınordu, Ordu, in the fall semester of the 2018-2019 academic year. There were 33 (male = 11, female = 22) students in the experimental group and 33 (male = 13, female = 20) students in the control group. In the sample selection of the study, a simple random sampling method was used. In this method, all units have an equal chance of being selected for the sample (Büyüköztürk, et al., 2010). Experimental and control groups were randomly selected within the classes created in the schools.

Data Collection

In this research, Scientific Creativity Scale (SCS), Logical Thinking Group Test (LTGT), and Academic Achievement Test (AAT) were used.

Scientific Creativity Scale (SCS)

A scientific creativity scale was used to determine the students' scientific creativity scores at the beginning and end of the research. The scale was developed by Hu and Adey (2002). There were differences in some of the test items during the Turkish adaptation of the scale (Aktamış, 2007; Deniş Çeliker, 2012; Kadayıfçı, 2008). To use the scale, permission was obtained from Hu and Adey (2002) and Deniş Çeliker (2012), who also adapted the scale to Turkish. Deniş Çeliker (2012) calculated the scale's reliability to be 0.86. Hu and Adey (2002) wrote 48 questions, two for each dimension. By evaluating the opinions of 50 science educators, they reduced the number of questions to nine. The pre-application of the nine-question test was carried out with 60 students and evaluated, and the test took its final form with seven items. Each item in the test aims to measure more than one of the parts in the model. In this study, the scale's reliability was found to be 0.82.

Logical Thinking Group Test (LTGT)

Students are expected to determine logical thinking skills before and after the research. Therefore, the Logical Thinking Group Test was used. The scale was developed by Roadrangka, Yeany, and Padilla (1982). Then, Sert Çıbık (2006) used adopting. Necessary permissions were obtained from the author (Sert Çıbık, 2006) for the use of the scale. Reliability studies were conducted, and the scale's Cronbach Alpha internal consistency coefficient was calculated as 0.88. The scale consists of 21 items in total. The first 18 questions part of the test consists of multiple-choice questions. When students give correct answers to multiple-choice questions, they get a "1" point; when they give wrong answers, they get a "0" point. The last three questions in the test consist of open-ended questions. "1" point is given for correct answers, and "0" point is given for incorrect answers. The researchers scored the results obtained. The answer key in the original form of the test was used to evaluate open-ended questions. The test does not consist of a factored structure. In this study, A rubric was used in the scoring process. The scale's Cronbach Alpha internal consistency coefficient was calculated as 0.80.

Academic Achievement Test (AAT)

An academic achievement test was used to measure students' academic achievement differences. An academic achievement test developed by Kaya (2015) was used. As a result of different adaptations, validity and reliability studies were performed for the test. The academic achievement test, adapted for a validity study, was examined by two science teachers and two science educators, and the structure and scope validity were ensured. Also, it was evaluated whether the achievement test was acceptable for the target students, according to the expert's assessment. The reliability of the test was calculated using the KR-20 formula. The internal consistency coefficient KR-20 was calculated as 0.81. In this study, the internal consistency coefficient KR-20 was calculated as 0.86. Students get a minimum of 0 and 16 points from the solar system and beyond academic achievement tests.

Development of Modeling

The "Solar System and Beyond" unit comprises many subjects and concepts. It includes concepts that require students to have a high level of scientific creativity, and scientific and logical thinking skills. When the literature is reviewed, it can be seen that students have various misconceptions (Emrahoğlu & Öztürk, 2009; Şenel Çoruhlu & Çepni, 2015). Below are some misconceptions in the literature on the subject.

- The stars move, so they stay behind the Earth during the day and are invisible.
- The stars reflect the light they receive from the Sun.
- The stars are smaller than the Sun.
- The size of the Moon changes according to its phases of the Moon.
- If the Moon's rotation period were different from the rotation period of the Earth, the illuminated surface of the Moon would be less.

• The Sun revolves around the Earth.

• As the Earth revolves around the Sun, the Sun appears in different places from the Earth (Göncü, 2013; Şenel Çoruhlu & Çepni, 2015).

For this reason, it is aimed for the modeling planned to be developed to increase academic achievement and develop students' comprehension levels, scientific creativity, and logical reasoning. "Solar System and Beyond" unit student attainments were analyzed for the modeling the students were supposed to prepare. The planned modeling was presented to experts in the field, science educators, and teachers. The feedback indicates that the models suit students' levels and teaching concepts. As a result of the feedback received, the modeling students were supposed to make was decided upon. The identified models are then performed in groups by the students in the experimental group. All materials for models are provided to students. Students develop models in groups in the light of specified guidelines. The visuals of the models and modeling process are below (see. Figure 1).

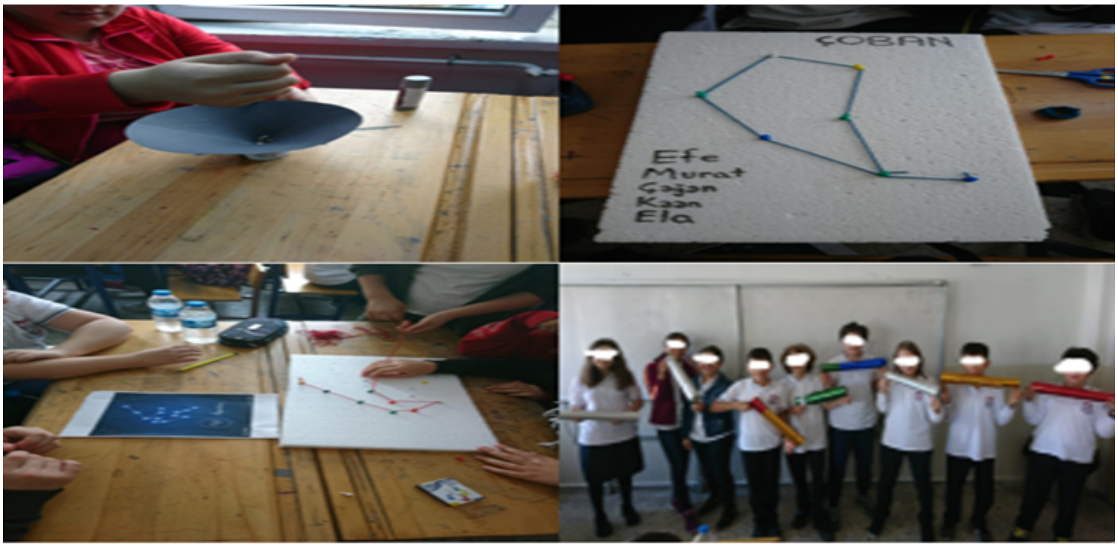

Figure 1. *Experimental group modeling process and model examples*

Designing Computer-Aided Teaching Materials

For computer-aided teaching applications of the "Solar System and Beyond" unit, it is aimed to choose between animations developed by Kaya (2015) and animations that are free to use. Animations considered for use were determined by field experts, science educators, and teachers. Animations intended for use were decided from the pilot application and student feedback. The experimental group participated in modeling and computer-aided learning activities based on the unit's progression of goals. The experimental group performs activities aimed at the solar system and beyond applications in the pre-developed computer class. The interfaces of the animations used and the visuals of the classroom environment during computer-aided teaching are given below (see. Figure 2).

Figure 2. *Interfaces of computer-aided teaching applications and materials*

Research Process

The research process was carried out sequentially with the planned steps. First, the materials used in modeling and computer-aided teaching were determined by considering student attainments. When the student attainments of the "Solar System and Beyond" unit are examined, students need to visualize many concepts in their minds. Therefore, it aims to develop students' scientific creativity and logical thinking skills to enable them to visualize these concepts more comfortably. For this reason, materials that aim to develop scientific creativity and logical thinking skills are used in modeling and computer-aided teaching. Before conducting the study, a pilot application was made to test the experimental process in addition to material and data collection tools. After the pilot application, the study was finalized based on the feedback from science educators, teachers, and students. The feedback consists of comments about the duration of the activities planned to take place. The duration of the lessons and the realization of the activities were reviewed. As a result, it was decided that the activities were carried out not individually but in groups. As a result, it was decided that the activities were carried out not individually but in groups. Especially plastic, cardboard, and similar materials were used.

In the experimental group, modeling, and computer-aided teaching were performed in addition to the science teaching program. The control group's lessons are based on the national curriculum (MEB,2018). The mutual features of the groups are stated as the information and practices in the coursebook and curriculum. Student attainments of the "Solar system and beyond" unit are shown in Table 1.

Table 1. Student attainments of the "Solar system and beyond" unit

Number System	Student attainments
F.7.1.1.1.	Can explain space technologies.
F.7.1.1.2.	Can express the causes of space pollution and estimate the possible results of this pollution.
F.7.1.1.3.	Can explain the relationship between technology and space research.
F.7.1.1.4.	Can explain the structure and functions of the telescope.
F.7.1.1.5.	Can make inferences about the importance of telescope in the development of astronomy.
F.7.1.1.6.	Can prepare and present a simple telescope.
F.7.1.2.1.	Can realize the star formation process.
F.7.1.2.2.	Can explain the concept of a star.
F.7.1.2.3.	Can explain the structure of galaxies.
F.7.1.2.4.	Can explain the concept of the universe.

In addition to the science curriculum, some modeling and computer-aided education activities below were applied to the students in the experimental group for the relevant learning goal. Unlike the control group, it is planned to carry out modeling and computer-aided education activities to teach the relevant learning goal. In addition, it is aimed at supporting the teacher of the course in the execution of the activities by the researchers. The experimental process applied to the experimental group is shown in Table 2.

Table 2. The experimental process applied to the experimental group.

Experimental group		
Implementation of Pretests		
First Week	Lesson 1 Lesson 2 Lesson 3 Lesson 4	F.7.1.1.1. Can explain space technologies. F.7.1.1.2. Can express the causes of space pollution and estimate the possible results of this pollution. F.7.1.1.3. Can explain the relationship between technology and space research. In the experimental group, it was planned to be carried out in the first week and the first four-hour lesson period following the above-mentioned science curriculum. In addition to the science curriculum, some modelling and Computer-Aided education activities were applied to the students in the experimental group for the relevant learning goal. - During the first and second lesson hours, various models related to space technologies were introduced to the students in the experimental group in addition to the control group. These models include space technology such as the space shuttle, astronauts, and artificial satellites. The design process of the models consists of models made by pre-service teachers within the scope of the astronomy course of a state university. The activity allowed students to study space technologies in groups using the method of physically modeling. Pre-service teachers designed models in light of achievements in the science curriculum. The process was conducted under the supervision of a science educator and a physical educator.

		Experimental group students performed the related activity in the 8-10 minutes of the lesson. - For the third and fourth lesson hours, activities were designed for the students to learn the relevant learning outcomes better with the Computer-Aided teaching method. In the last 25 minutes of the 80-minute course, students were given an animation study about the technologies that space technology adds to our daily lives and the spacecraft used in space. The students were asked to examine the animations that meet the relevant acquisitions on the smart board in the classroom with their colleagues. Each group consists of 3-4 students. Each student group has an average of 1-1.5 minutes. In the control group, the lessons continue in light of the contents contained in the textbook by the teacher.
Second Week	Lesson 5 Lesson 6 Lesson 7 Lesson 8	F.7.1.1.4. Can explain the structure and functions of the telescope. F.7.1.1.5. Can make inferences about the importance of telescope in the development of astronomy. F.7.1.1.6. Can prepare and present a simple telescope. In the experimental group, in addition to the control group, the second week focused on preparing a telescope model. Although the control group had the activity of preparing a telescope model for the last learning outcome, students did not prepare following the outcome and could not design a fully successful telescope model. In the experimental group, at the end of the fifth and sixth lesson hours, an animation explaining the historical development and importance of the telescope was presented with a smart board for 5-7 minutes. In addition, the students were asked to create two-dimensional models by giving the CVs and photographs of famous Turkish-Islamic astronomers in a mixed form, matching the information they learned in the lesson, and then sticking them on cardboard. This activity corresponds to a duration of approximately 10-13 minutes. The last lesson of the second week was reserved for the preparation of the telescope model as a modeling activity for the experimental group. The students were formed into groups of 3-4 people primarily for teamwork. Then, after the related materials were distributed to each student group, information about the process was given. After completing the telescope models in approximately 15-20 minutes, each student group was asked to introduce the telescope models which they developed. In the control group, the program was also planned by the teacher.
Third Week	Lesson 9 Lesson 10 Lesson 11 Lesson 12	F.7.1.2.1. Can realize the star formation process. F.7.1.2.2. Can explain the concept of a star. Different from the control group, various modeling, and Computer-Aided applications were planned for the students in the experimental group. For the formation of constellations and substantial constellations, we planned to perform a matching simulation of students in groups of 2-3. The activity was allocated approximately 1-1.5 minutes for each group. In addition, a modeling activity related to the constellations was planned with the students in the last lesson of the 3rd week. In this activity, students are divided into groups of 3-4 people. Styrofoam foam is distributed to the students for the constellation's activity. Afterward, students are given a visual containing various constellation. With the help of colored large-headed pins and threads, students are asked to create the constellations in the image. The activity period covers one lesson hour. In the control group, the program was also planned by the teacher.
Fourth Week	Lesson 13 Lesson 14 Lesson 15 Lesson 16	F.7.1.2.3. Can explain the structure of galaxies. F.7.1.2.4. Can explain the concept of the universe. In the last week, animations about the formation of the galaxy and the concept of the universe were presented to the students in 5-7 minutes via a smart board for the final learning outcomes of the unit. With this, a modeling activity was planned for the students regarding the concept of a black hole. The students were asked to perform the activity in groups of 3-4 people, approximately 20-25 minutes. In this event, cardboard and beads are distributed first. Students are asked to prepare the cardboard in the shape of a funnel and then toss the beads into this funnel. In this way, an activity related to the concept of a black hole is realized. In the control group, the program was also planned by the teacher.
Implementation of post-tests		

Research Ethics

This study is ethically appropriate with the 2018 decision number of the Social and humanities research ethics committee of Ordu University dated 11.09.2018 and numbered 03. The students' personal data were not shared with third parties during the study's experimental process. In addition, it aims to comply with the ethical rules by giving references and obtaining the necessary permissions for all measurement tools used in the study.

FINDINGS

In this section, the findings of the research are presented. The descriptive analysis results of the sub-dimensions that constitute the scientific creativity scale are presented in Table 3. Also, the normality test results for SCS are presented in Table 4.

Table 3. Pre -Post Test Results of SCS Sub-dimensions of Control and Experimental Groups

Question	Experimental Group				Control Group			
	Pre-Test		Post-Test		Pre-Test		Post-Test	
	x̄	SS	x̄	SS	x̄	SS	x̄	SS
Unusual Uses	3.06	1.53	5.18	2.54	4.33	3.74	4.21	3.24
Discovering The Problem	3.87	2.44	6.84	2.82	5.00	3.01	5.30	3.21
Product Development	3.12	0.89	5.27	2.49	5.12	2.39	4.12	2.38
Scientific Imagination	3.18	1.40	5.45	2.59	4.75	1.87	5.09	1.80
Problem-Solving	1.84	0.79	2.03	0.58	2.18	1.10	2.48	1.12
Science Experiment	4.15	1.69	7.78	1.21	6.54	2.15	3.12	1.93
Product Design	7.6970	2.2006	13.909	1.5883	10.4848	3.1237	12.0303	2.8447

Table 4. Shapiro-Wilk Results of Control and Experimental Group's SCS Pre-Test Scores

Group	Statistics	df	p
Experimental Group	0.937	33	0.540
Control Group	0.930	33	0.036

As a result of the Shapiro-Wilk normality test, the experimental group did not show a normal distribution. Mann Whitney U test was performed because the data did not show normal distribution.

Table 5. Control and Experimental Group SCS Pre-Test Mann Whitney U Test Results

Group	N	Mean Rank	Sum of Ranks	U	z	p
Control Group	33	37.24	1129.0	421.00	-1.558	0.112
Experimental Group	33	29.76	982.0			
Total	66					

When Mann-Whitney U results were examined in Table 5, there was no significant difference between the student's pre-test scores (U:421.00; p>0,05). When the mean values are considered, they have a higher average regarding scientific creativity compared to the control group. However, more than this situation is needed for a statistically significant difference.

Table 6. SCS Wilcoxon Sign Test Results of the Experimental Group

Before Education-After Education	N	Mean Rank	Sum of Ranks	Z	p
Negative Ranks	6	9.00	54.00	-4.049	0.000
Positive Ranks	27	18.78	507.00		
Total	0				

According to the results obtained in Table 6, in the experimental group, there is a significant difference between the pre-test and post-test in terms of the scientific creativity scale scores of the students. (z=-4.049; p<0,05).

Based on the Science Curriculum, there was no significant difference between the pre-test and post-test Scientific Creativity scores of the students in the control group. Since the data do not show a normal distribution, Table 7 shows the results of the Wilcoxon signal test.

Table 7. SCS Wilcoxon Sign Test Results of the Control Group

Before Education-After Education	N	Mean Rank	Sum of Ranks	Z	p
Negative Ranks	16	13.63	218.00	-0.299	0.765
Positive Ranks	14	17.64	247.00		
Total	3				

Table 7 shows no significant difference between the scientific creativity scale scores of the control group students (z=-0.299; p>0,05). The research tested the significant difference between the experimental and control group post-test Scientific Creativity scores with the Modeling and Computer-Aided Learning methods.

Table 8. Control and Experimental Group SCS Post-test Mann Whitney U Test Results

Group	N	Mean Rank	Sum of Ranks	U	z	p
Control Group	33	25.27	834.00	273.00	-3.486	0.000
Experimental Group	33	41.73	1377.00			
Total	66					

Table 8 shows a significant difference between the groups due to Mann-Whitney U (U:273.00; p<0,05). However, when the means are examined, it is seen that the experimental group has more points and makes a significant difference. The results of the descriptive analysis of the sub-dimensions of the scientific creativity scale are presented in Table 3.

In the study, a significant difference was tested between the pre-test LTGT scores of the students in the experimental group and those in the control group. Also, the normality test results for LTGT are presented in Table 9.

Table 9. Shapiro-Wilk Scores of LTGT Scores of Controls and Experimental Groups Results

Group	Statistics	df	p
Experimental Group	0.949	33	0.121
Control Group	0.936	33	0.530

The scores obtained by the control and experimental groups from the LTGT pre-test show normal distribution, and the independent group's t-test results are presented in Table 10 for this purpose.

Table 10. Control and Experimental Group LTGT Pre-test Independent Samples t-Test Results

Group	N	x̄	S	Sd	t	p
Control Group	33	3.6970	2.3114	64	-1.130	0.787
Experimental Group	33	3.0606	2.2630			
Total	66					

When Table 10 is examined, it is seen that there is no significant difference between the scores of the experimental and control groups from the LTGT pre-test. The research found a significant difference between the pre-test and post-test Logical Thinking Group Scores of the experimental group students studying with the Modeling and Computer-Aided Learning method. The LTGT scores of the experimental group showed normal distribution, and the dependent group's t-test was performed for this purpose.

Table 11. LTGT Pre-Post Test Dependent Samples t-Test Results of Experimental Group

Group	N	x̄	SS	Sd	t	p
Pre-Test	33	3.06	2.263	32	-4.735	0.000
Post Test	33	5.45	2.017			
Total	66					

According to Table 11, a significant difference was found between the LTGT scores of the experimental group. The research tested a significant difference between the pre-test and post-test Logical Thinking Group scores of the control group students. The control group's scores from the LTGT pre-post test showed a normal distribution, and the dependent groups were subjected to a t-test.

Table 12. Control Group LTGT Pre-Post Test Dependent Samples t-Test Results

Group	N	x̄	SS	Sd	t	p
Pre-Test	33	3.370	2.311	32	-0.391	0.698
Post Test	33	3.394	2.221			
Total	66					

According to Table 12, it is seen that there is no significant difference between the LTGT of the control group students. The study tested a significant difference between the experimental and control group students' post-test Logical Thinking Group scores. An Independent data t-test was performed because the data showed normal distribution.

Table 13. Control and Experimental Group LTGT Post-test Independent Samples t-Test Results

Group	N	x̄	SS	Sd	t	p
Control Group	33	3.9394	2.2212	64	2.901	0.005
Experimental Group	33	5.4545	2.0169			
Total	66					

According to Table 13, it was found that there was a significant difference between the groups' scores obtained from the LTGT post-test. Also, the normality test results for AAT are presented in Table 14.

Table 14. Shapiro-Wilk Results of Control and Experimental Group's AAT Pre-Test Scores

Group	Statistics	df	p
Experimental Group	0.969	33	0.448
Control Group	0.953	33	0.163

In the study, a significant difference was tested between the pre-test academic achievement scores of the students in the experimental group and those in the control group. The Mann-Whitney U test was performed because the data did not show normal distribution.

Table 15. Control and Experimental Group AAT Pre-Test Mann Whitney U Test Results

Group	N	Mean Rank	Sum of Ranks	U	z	p
Control Group	33	34.23	1129.50	520.50	-0.321	0.756
Experimental Group	33	32.77	1081.50			
Total	66					

When the Mann-Whitney U results were examined according to Table 15, it was found that there was no significant difference between the groups (U: 520.50; $p <0.05$). However, when the averages are taken into consideration, it is seen that the mean of the control group is higher but does not make a significant difference. Since the data did not show normal distribution, the Wilcoxon sign test was performed. Wilcoxon signal test results are presented in Table 16.

Table 16. AAT Pre-Post Test Wilcoxon Sign Test Results of Experimental Group

Before Education-After Education	N	Row Average	Row Total	Z	p
Negative row	2	11.75	23.50	-4.598	0.000
Postive row	31	17.34	537.50		
Equal	0				

Table 16 shows a significant difference between the academic achievement test scores of the experimental group (z = -4.598; p <0.05). The research found a significant difference between the pre-test and post-test Academic Achievement scores of the control group students.

Table 17. AAT Pre- Post Test Wilcoxon Sign Test Results of Control Group

Before Education-After Education	N	Mean Rank	Sum of Ranks	Z	p
Negative Ranks	3	7.17	51.50	-4.545	0.000
Positive Ranks	29	17.47	506.50		
Total	1				

Table 17 shows a significant difference between the scores of the control group students (z = -4.545; p <0.05). In the research, a significant difference was found between the post-test Academic Achievement scores of the experimental group and the students in the control group. The data obtained from the Academic Achievement test were first tested for normality. AAT scores of the groups were not normally distributed, and the Mann-Whitney U test was performed for this purpose.

Table 18. Control and Experimental Group AAT Post-Test Mann Whitney U Test Results

Group	N	Mean Rank	Sum of Ranks	U	z	p
Control Group	33	24.23	799.50	238.500	-3.956	0.000
Experimental Group	33	42.77	1411.50			
Total	66					

Table 15-18 shows no significant difference between the groups' scores from AAT. (U: 238.500; p <0.05). When the averages are taken into consideration, it is seen that the control group has a higher average, and this difference is significant.

DISCUSSION AND CONCLUSION

This study investigated the effects of modeling and computer-aided teaching on the creative thinking, logical thinking skills, and academic achievement of seventh-grade students. The correlation between creative thinking, logical thinking skills, and academic achievement has yet to be studied. The quantitative findings obtained during the study were analyzed and interpreted using various statistical methods. The scores of students from the scientific creativity scale were analyzed. Before the study, no significant difference was found between the scores of students from the SCS pre-test (Table 5). The result of no significant differences shows that the students had similar levels. There was no difference in the pre-test results between the experimental and control groups. In such cases, the experiment and control group are at a similar level (Korkut, 2005). The fact that the students have a similar level contributes to a more accurate measurement of the quality of pre-test and post-test scores of the experimental group compared to those within the group. A statistically significant difference exists between the experimental group's pre-test and post-test scientific creativity scores (Table 5). There is no statistically significant difference between the control group's pre-test and post-test scientific creativity scores (Table 7). Post-test scientific creativity scores of the groups were compared with statistically significant differences between the scientific creativity scale scores of the group's students (Table 8). When experimental group students were compared with the control group students, they were found to get higher scores on the scientific creativity scale. The amount of development in the scientific creativity levels of students was found to be higher in the experimental group, which received modeling and computer-aided teaching compared with the control group. Similarities were found in pre-test scores when the scientific creativity scale subscales were examined.

When the scientific creativity scale is examined, there are similarities between the groups regarding the pre-test results of the scientific creativity scale according to the descriptive results. Post-test scores of the groups from scientific creativity scale subscales were analyzed. Experimental group students were found to have higher arithmetic mean than control group students (Table 3). The main possible reason for this difference is that students' modeling and computer-aided teaching materials enrich the learning process from various aspects. The foundations of scientific creativity consist of eight sub-dimensions (Demir, 2015). It is essential to use appropriate teaching materials to develop each sub-dimension. Computer-aided and modeling-assisted teaching develops students' scientific creativity by developing alternative, probability, and different thinking skills.

At the same time, scientific creativity is supported by the attainments that constitute the modeling and computer-aided teaching academic achievement test applied in astronomy. When the literature is reviewed, studies supporting the results of the present study can be found (Arslan, 2013; Demirhan, 2015; Ulukök, 2012). Studies show that computer-aided and modeling-based teaching contributes to developing many skills, especially scientific creativity. Students' preliminary and final test scores are qualified as proof of this condition. However, some studies contradict the present study, stating that computer-aided or modeling-assisted teaching does not affect students' scientific creativity (Bolu, 2017). Bolu (2017) researched the effect of modeling-based science education on students' creativity regarding the "Transmission of Electricity." As a result of the study, it was concluded that modeling-based science education did not cause a positive development in students' creativity levels regarding the "Transmission of Electricity." On the other hand, computer and modeling-assisted teaching increases students' scientific creativity (Arslan, 2013; Bolu, 2017). In addition to the findings of this study, some studies found no difference between the experimental and control groups regarding students' scientific creativity (Demirhan, 2015).

Especially in our age, transforming information into different forms increases the importance of computer and modeling-assisted teaching methods. Students must offer their learning methods and alternative solutions regarding their scientific creativity. Individuals with scientific creativity are more likely to develop other skill levels (Aktamış & Ergin, 2007).

Students' scores from the logical thinking skills scale were analyzed statistically. No statistically significant difference was found between the pre-test experimental and control groups' logical thinking skills scale scores (Table 10). The result of no significant difference between the groups shows similar levels (Korkut, 2005). Pre and post-test LTGT scores of the experimental group were compared within the groups, and statistically significant difference was found (Table 11). No statistically significant difference was found between the control group's pre and post-application logical thinking skills scale scores (Table 12). Post-test logical thinking skills scores of the groups were compared. There is a significant difference between groups regarding the experimental group (see. Table 13). Experimental group students were found to get significantly higher scores on the logical thinking scale when compared with the control group that was taught with the science curriculum. Compared with traditional methods, students taught with modeling and computer-aided teaching were found to have higher logical thinking skills. When the literature was reviewed, studies with significant differences in favor of the experimental group were found (Çığrık, 2009; Yıldıran, 2004). However, no studies were found in the literature investigating the effects of computer-aided and modeling-assisted teaching on logical thinking skills. However, there are studies in which it has been found that, in contrast to the meaningful effect included in this study, it has no effect or negative effect on logical thinking skills (Ballıel, 2014; Demir, 2004; Demirer, 2009; Gökçe, 2015; Kaplan, 2007). Gökçe (2015) researched the effects of computer-aided teaching on students' logical thinking skills about the "Acids-Bases" subject. No difference was found between the groups in terms of logical thinking skills. Ergün (2013) examined whether model-based activities affected students' logical thinking skills on atom and molecule subjects. The study results showed that model-based activities helped students with high logical thinking skills comprehend the particulate nature of matter in atom and molecule subjects. At the same time, they had lower rates of misconception regarding atom and molecule concepts when compared with students with low logical thinking skills.

The student's scores from the academic achievement scale were analyzed statistically. There were no statistically significant differences between the groups' pre-test academic achievement scale scores (Table 15). Pre and post-test academic achievement scale scores of the experimental group were compared. Statistically, a significant difference was found between the scores of the experimental group students. Statistically, a significant difference was found between the pre-test and post-test academic achievement scores of control group students (Table 17). The renewed lesson curriculum is expected to increase the control group's academic achievement.

For this reason, the comparisons of groups are made through arithmetic means (Pallant, 2016). Post-test academic achievement test scores of groups were compared. Significant differences were found between groups in favor of the experimental group (Table 18). The arithmetic means of the experimental group students were found to be higher than those of the control group. Academic achievement test dimensions were examined. When the students in the experimental group were compared with those in the control group, academic achievement test sub-dimension arithmetic means were higher. When literature is examined, it is seen that computer or modeling-supported teaching increases academic success studies (Bilal, 2010; Bolu, 2017; Kölemen, 2018; Mor, 2016; Namlı, 2018; Pamuk, 2018; Türk, 2015; Ulusoy, 2011; Ünal, 2005; Zengin, 2019; Zorlu, 2016;).

Unlike the traditional method, computer and modeling-assisted teaching increase individuals' scientific creativity, logical thinking skills, and academic achievement. The reason for this difference between the groups is the modeling and computer-aided teaching in the experimental group. Since this teaching was carried out in addition to the control group, it contributed to students' skills. During the modeling process, the students are asked to control various variables and use more than one skill. For this reason, during the modeling process, students develop their investigative and questioning aspects and psychomotor skills (Demir, 2017). In addition, computer-aided teaching contributes to many students' skills since it includes various software and hardware elements. As seen from the study results, it also develops scientific creativity, logical thinking skills, and academic achievement. It provides significant opportunities for students to develop the skills they have. It contributes to alternative thinking instead of usual questions and answers. Using the two methods together positively affects students' creative thinking skills. As a result of the study, a statistically significant difference can be seen in the experimental group in which computer and modeling-assisted teaching was carried out. Although the result can be statistically generalized, the number of students in the experimental and control groups is relatively low. The theoretical foundations of the ARCS teaching model and the theoretical framework of the study are also common ground. Based on the ARCS instructional design model, it aims to increase the student's motivation, interest, and curiosity toward the course (Hsia, Lai & Su, 2022).

Suggestions

Difficulties and ideas were encountered during and after the study, and suggestions were made to the researchers for further studies. The province where the research is carried out can be changed in subsequent studies to obtain different results. At the same time, changes in the number of samples may reveal different dimensions of the research. After this study, which is limited to the seventh grade "Solar System and Beyond," different units and subjects can be studied. In addition, applications can be made at the seventh-grade level and in all science units and subjects starting from preschool. The data collection tools of the study were determined to reveal the different learning products of the students. In addition, it is recommended that teachers make plans for using time. Planning has an essential place in systematically carrying out planned classroom activities. At the same time, it is recommended that teachers learn various program languages and take in-service training to create products. Further studies can include experimental and control groups with more extended periods and more participants. Conducting studies involving experimental and control groups of individuals from different sociocultural and socioeconomic levels is also recommended.

Limitations

This research is limited to the opinions of 66 students in primary schools in Ordu city center on “Scientific Creativity Scale (SCS)”, “Logical Thinking Group Test (LTGT)”, and “Academic Achievement Test (AAT)” scales.

Statements of Publication Ethics

This study is ethically appropriate with the 2018 decision number of the social and humanities research ethics committee of Ordu University dated 11.09.2018 and numbered 03.

Researchers’ Contribution Rate

The contributions of the authors to this study are detailed in Table

Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Author 1’s name	☒	☒	☒	☒	☒	☒
Author2’s name	☒	☒	☒	☐	☒	☒
Author 3’s name	☒	☐	☒	☒	☒	☒

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