The Effect of the Computer-Based Analogy Used in Science Teaching on Learning Outcomes

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ABSTRACT

The aim of this study is to examine the effects of computer-based analogy (CBA) used in science teaching in terms of the unit of Structure and Properties of Matter on seventh-grade students' academic success. The attitudes of students against science teaching lesson were also described in this study. This study was applied to 60 seventh-grade students from two different classes of the same teacher from a public school in Köprübaşı/Trabzon. In the study, pre-test – post-test control group quasi-experimental research model was used. The remarks of the students were described by content analysis within the context of qualitative research method. During the research period, computer-based analogy method was applied to the experimental group; on the other hand, traditional teaching method was applied to the control group. In the study, quantitative data as data collection tool was collected through academic success test prepared by the researcher. On the other hand, qualitative data was collected through an interview form, including open-ended questions formed by consulting experts. The results of the study show that the computer-based analogy method is more effective than the present program applications in terms of students' academic success in science lessons and permanence of knowledge. The results of the qualitative data analysis show that the students had positive views related to the lesson made by the computer-based analogy method.

Keywords: Science education, analogy method, computer-based teaching, the structure and properties of matter.

INTRODUCTION

Because the subjects and concepts included in the science courses are abstract and theoretical, it is determined that many students have difficulty in perceiving the concepts of science (Anagün, Ağır and Kaynaş, 2010; Ayas and Özmen, 1998; Balkan Kıyıcı, 2008) and therefore, they have developed negative attitudes toward science (Hannover and Kessel, 2004). Today, science education is evaluated with an epistemological approach, focusing on the role of learners in the personal construction of knowledge (Atasoy, 2004; Hewson, 1992; Ritchie and Russell, 1991). Determining the ideas of the students and correcting them if they are wrong are indispensable for the subsequent learning (Karamustafaoğlu, Özmen and Ayvacı, 2004). The new information will be better understood and remembered when it is meaningful for the student. Analogies are of great importance in learning, as they can help in reconfiguring existing memory and preparing for new knowledge (Gentner, 1983). Analogy is one of the ways of reasoning; reasoning is defined as the elimination of one another from the relationship between at least two propositions (Çüçen, 1997; Kesercioğlu, Yılmaz, Çavaş and Çavaş, 2004). Analogical thinking plays a key role in the constructivist learning process. In the structuring process of the concepts, analogies have a facilitating effect (Demir, Önen and Şahin, 2011; Duit, 1991; Ekici, Ekici and Aydın, 2007).

Newton (2003) categorized the analogies into four: simple, enriched, extended, and metaphor. The simplest analogies in these categories include analogies that emphasize a single similarity dimension, which is not detailed and which is expressed in a similar manner to the target source without explanation. Enriched analogies include a few sources for a target; they are used in simulations that contain more than one similar aspect of the source to identify the target. Expanded metaphors are used in relations between source and new content, as well as in their limitations; in other words, metaphors are used when the daily language of life is the same as the relationship between the target and the source.

When the use of analogy and metaphors in teaching is examined, it is noteworthy that it is the teaching models that make comparisons with similarities between the two systems or elements (Aubusson, Harrison, and Ritchie, 2006; Çelik, 2016; Forceville, 2002), but that carries out this process in different ways. The difference between analogy and metaphor is whether modelling is made explicitly by the nature of comparison (Taber, 2001). The similarity was established during the creation of analogies; similarities, differences, qualifications, and inadequacies should be included between the analogy and target concept (Kesercioğlu, Yılmaz, Çavaş & Çavaş, 2004). In this study, simple, enriched, and expanded analogies were used.

Treagust, Harrison, and Venville (1998) summarized the importance of analogies, which are powerful learning techniques, in science teaching:
- Provides a clear understanding of the concepts from different perspectives.
- Enables learners to gain real-world experience.
- Helps to teach the concepts clearly from a different perspective.
- Summarizes topics in an easily-understandable form.
- Motivates learners by attracting their interests.
- Provides difficult information for learners and teachers to see their mistakes easily.
- Facilitates access to information, concept development, and problem solving.
- Makes unknowns compatible with logic by improving creativity.

When the related items are examined; It can be said that analogies are very important for science teaching in classes and textbooks as it facilitates learning (Guerra-Ramos, 2011; Vosniadou and Skopeliti, 2019). The types of knowledge contained in the sciences are full of abstract concepts that are difficult to understand, as long as they are not linked to our daily experiences (Orgill and Bodner, 2004). There are many different methods and techniques that can be used in the learning environment to teach abstract events, phenomena, concepts, and

complex processes and to enrich in-class activities. In the student-centered learning approach, in order to avoid memorized information, combine the information given to the students with the knowledge they had previously, and try to ensure the active participation of the students in learning, technology-supported education is a useful method in providing the students with rich and self-contained learning activities (Özmen, 2004).

Technology support is an undeniable fact especially in understanding abstract concepts in science education. In this context, simulation and animation programs are widely used. Simulation is the realization of a subject, system, and event model on a computer. It is widely used in understanding abstract concepts by giving education in laboratories instead of expensive and real environments (Altın, 2009). Animation is the process of manipulating and changing by activating static pictures or images (Akpınar, 2005). Animations can be composed of real images taken with video or they can be displayed as moving images on computer after processing (Altın, 2009).

In order to support the teaching of abstract and complex science subjects in science teaching, analogies are included in the Computer Aided Teaching (CAT) material. While preparing the analogies, it is necessary to take into account the persistence of science teaching, which is intended to be realized, as well as better structuring of knowledge for students. In this context, while creating analogies, it is thought that the use of audiovisual features such as animation, sound effect, color, and moving picture will ease the cognitive burden of knowledge; thus, the science teaching, which is aimed to be realized, will be made more permanent. In the science and technology course dominated by abstract subjects, the use of CAT materials enriched with animation, simulation, video and multimedia, and other supporting techniques in science education is known to increase the interest of students (Akçay, Tüysüz and Feyzioğlu, 2003) and to decrease the spent time for achieving the goal in terms of teachers and students (Kulik, Kulik and Bangert-Drowns, 1985).

In recent years, analogies are considered to be one of the most important elements in science-related teaching-learning process (Azizoğlu, Çamurcu and Kırtak Ad, 2014; Dagher, 1995; Duit, 1991; Garde, 1986; Kılıç, 2007; Paul, Lim, Salleh, & Shahrill, 2019; Thiele and Treagust, 1994, Yılmaz, Eryılmaz and Geban, 2002). In science, teaching concept is very important and students learn the concepts and combine the situations they have learned previously with new situations and simulations in their minds. When we look at the writings of mental processing based on this simulation, we see as analogy, metaphor, mental image, image, or mental model. These concepts serve to the same process in the science and social sciences in the literature (Çelik and Çakır, 2015; Çökelez and Yalçın, 2012; Güveli, İpek, Atasoy and Güveli, 2011; Kavak, 2007; Ören, Ormancı, Babacan, Koparan and Flower, 20; Özdemir, 2012).

There are many concepts of abstract nature that students cannot see in terms of the granular structure of matter. For example, atom is one of the building blocks of science and its importance increases with the developing science and technology. This concept is mentioned in the elementary science and technology curriculum (MEB, 2006) in the area of learning "matter and change". Ensuring that the concept of atom in the science education is structured in a way desired by the students is becoming more important for science education in teaching different concepts (Çökelez and Yalçın, 2012). One of the analogies very widely used in science teaching is to simulate atom to a small solar system. Taber (2001) classifies the justification of an analogy in this way as follows:

1. The concept of atom is abstract and it will be difficult for children to understand its structure.

2. Atom is like a small solar system in some respects.

3. Children know solar system well.

4. The clear comparison of solar system with atom creates a useful starting score for learners about the atomic structure.

In addition to the above-mentioned emphasis in teaching the atom concept through analogy, the support of the visual simulations with the computer-based learning environment can increase the expected benefits. Due to the fact that the particles at the molecular level involved in the structure and properties of matter are mobile and they contain dynamic processes between particles, the use of moving pictures in visualizing these dynamic processes can be more effective. Therefore, the general purpose of this study is to determine the effect of using CAT method on the students' academic success, knowledge retention, and attitudes toward science lesson during the teaching of "Structure and Properties of Matter" in the seventh-grade science and technology lesson at the secondary school.

For this purpose, we aimed to answer the following research questions:

1. Is there a significant difference between the pre-test score means of experimental group (CBA method is used) and pre-test score means of control group (traditional method is used)?
2. Is there a significant difference between the pre-test and post-test score means of control and experimental group students?
3. Is there a significant difference between the post-test score means of experimental group and post-test score means of control group?
4. Is there a significant difference between the permanence test score means of experimental group and permanence test score means of control group?
5. What are the attitudes of students in experimental group in terms of the science lesson where CBA method is performed?

METHODS

Both quantitative and qualitative research methods are included in the research. In this study, in order to investigate the effect of seventh-grade science and technology course on the students' academic success and the permanence of the knowledge learned, semi-experimental study was applied suitable to the pre-test/post-test model with the control group. In the pre-test/post-test control group patterns, the error term will be low and consequently the statistical power will be higher since the same students are measured (Büyüköztürk, 2016). An interview form was created to reveal the views of the students in the experimental group on the learning environments where the CAT method was applied.

As the quantitative and qualitative methods were used together, sequential pattern design was used for mixed research methods (Creswell and Plano Clark, 2014). In the research, in the qualitative and quantitative data, combination was done during the data analysis both to solve the situations where there are conflicts and to make the event rich and detailed by measuring it from different angles. In this design, qualitative data were collected after quantitative data were collected and analyzed in advance. This design is planned to be useful in terms of providing wide-ranging or alternative perspectives, supporting the participants of the research and providing a better understanding of the cases studied (Baki & Gökçek, 2012; Fırat, Yurdakul & Ersoy, 2014).

a) Study Group

The study was carried out with 60 students selected from seventh-grade students who were studying in two different classes in Köprübaşı Central Secondary School in Trabzon. Therefore, a mixed research method was applied and sequential and simultaneous mixed research samples were used. The sequential mixed method sample involves the selection of probabilistic and purposive sampling strategies (quantitative-qualitative) or (qualitative-

quantitative) sequential samples for a mixed method study. The last sample used in the quantitative stage is used as a determinant for sampling in the next qualitative stage (Baki and Gökçek, 2012).

b) Application

This study was carried out in the science and technology lesson in the spring semester of 2012-2013 academic years in two different classes of the secondary school in the Köprübaşı district of Trabzon. Application was made for 28 lesson hours (each course was 40 minutes and four hours per week, for a total of seven weeks). "Structure and Properties of Matter" was taught by the same teacher under the same conditions, with different teaching methods for the students in the experimental and control groups. During the application of "Structure and Properties of Matter", the sub-subjects of elements and symbols, structure of atom, array of electrons, chemical properties, and chemical bonds were created. In the lessons of the control group, while the applications were made for the present curriculum, in the experimental group the computer-based analogy (CBA) method was used for teaching (Annex-2). As an exemplary application, the analogy called "the formula of happiness, symbol of loneliness" was used for elements and symbols. The story style analogy was shown to the students and it was dramatized by them. The stories of "Love Story of Hydrogen and Oxygen" and "Surly Helium" are given by using analogy. In this process, similarities between analogy and target are classified by computer based on meaning analysis. Similarly, in the experimental group, the analogy of the world's common language (established between the traffic language and the language of science), electron view analogy (established between the electron micrographs and the appearance of the Chinese wall from space), analogy of gravitational force (concept given by flash-based animation application), the periodic table-Turkey plate codes analogy, elements and climates analogy, sub-particles of the atom analogy, atomic layer analogy, structure of atom analogy, hand in hand atomic model analogy, and Dalton's atomic model analogy are used. Microsoft Office software, animations, simulations, video, and images are used for applications.

In the experimental group, the students were informed about the analogy method and the features of the process. Simple, enriched, and extended analogies representing each category were prepared, as shown above, so that students could better understand the structure and properties of matter and increase their attitudes toward the course. The Academic Success Test (AST) was applied to the experimental and control groups in order to determine whether there was a significant difference between the classes before starting the practice.

c) Data Collection Tools

Academic Success Test (AST)

In accordance with the level of the students, a test consisting of 30 multiple-choice questions, including sub-topics of "elements and symbols of atom, structure of atoms, chemical properties, and chemical bonding" in "Structure and Properties of Matter", was developed by the researcher. The test was examined by specialized instructors to ensure the scope validity. The reliability study of the success test was conducted on 100 eight-grade students in three different schools with previously-studied research subject. The item difficulty values of the test items ranged from .46 to .83. If the item difficulty gets closer to .00, it is interpreted as hard, and if it gets closer to 1.00, it is interpreted as easy. When developing a test, items with .5 difficulty are preferred in terms of high item reliability and the ability of dividing knowing and unknowing. The item discriminant values of the AST vary between .30 and .67. Items with separation power below .20 are to be disposed, items

with .20-.40 need to be corrected, and items above .40 are very good items (Tan, 2005). As a result of the statistical procedures performed given the result of the item analysis, the difficulty indices and discrimination index of each item in the test were calculated. Academic success test with 26 questions was prepared. The results of the analysis of 26 items included in the scale are given in Annex-1. As the reliability of the AST, the value of KR-20, was found as .71, the success test had a level of reliability that could be used in the study.

Interview Form for Science and Technology Course

In the form of interview, six questions were included to determine the opinions of the seventh-grade students in the experimental group about the science lesson which was taught by the CBA method. In order to ensure the internal validity of the interview questions, two instructors and three science and technology teachers, who are experts in the field of questions, examined them; necessary corrections were made on the questions with their opinions. In this context, the questions included in the interview form are classified below:
1. What do you think about the applications of CBA in Science and Technology course?
2. Do you believe that writing analogy is beneficial? Why?
3. Have the practices contributed to improve your creativity? How?
4. With computer-based analogy, do you believe that the course contributes to the persistence of the knowledge? Please explain.
5. What are the positive and negative aspects of learning in the science and technology course with the CBA practices?
6. Would you like to learn the other subjects of science and technology in the same way? Why?

d) Data Analysis

In the research, the scores obtained from the academic success test of the students in the experimental and control groups were analyzed using SPSS package program. From the result of the experimental study, it was examined whether there was normal distribution of the data between the groups and in the groups. Since the number of people in the groups is smaller than 50, it is recommended to take the Shapiro-Wilk test results into consideration instead of Kolmogorov-Smirnov (Büyüköztürk, 2016). Covariance analysis (ANCOVA) was used to evaluate whether the difference between the corrected post-test mean scores of the groups was significant (Büyüköztürk, 2007). Calculations were made by considering $p < .01$ between the variables.

In order to support the data obtained in the study, an interview form consisting of open-ended questions was used to get the thoughts of the students about the science course, which was applied by the CBA method. Thirty participants were asked about the analogies used in science teaching. Content analysis method was used in the analysis of this data. The main purpose of content analysis is to reach the concepts that can explain the collected data (Yıldırım & Şimşek, 2005). Content analysis can be used in qualitative research, aimed at explaining or estimating (Büyüköztürk et al., 2008). For this purpose, common concepts were coded by using the data collected in the content analysis, and themes and sub-themes that may be included in these themes were tried to be created. The data were coded separately by both researchers and the themes were determined. A general coding has been done before coding. Then, after reviewing the said codes several times, themes emerged. After which, tables were created related to coding and themes. The answers of the students to the interview questions were recorded with the students' consent. The interviews on the recorder were documented. The students' identities were kept secret and each of them is given a number (Female student: K, Male student: E, #: student number).

FINDINGS

   a) **Findings for Quantitative Research**

   First Sub-problem: Is there a significant difference between the pre-test score means of experimental group (CBA method is used) and pre-test score means of control group (traditional method is used)? In order to obtain the findings of the first sub-problem, the results of the normality test of the scores of the students in the experimental and control groups were examined by Shapiro-Wilk test. The results of this test are shown in Table 1.

Table 1. *Shapiro-Wilk results of the normality test of the scores taken from the pre-test of the experimental and control group students*

Group	Statistics	Sd	p
Experimental	.93	30	.06
Control	.90	30	.08

   When Table 1 is examined, it is seen that both of the experimental and control groups have p values greater than .05. According to this, it can be said that the pre-test scores of the experimental group and the control group had a normal distribution. In order to determine a significant difference between the AST pre-test scores of the students in the experimental and control groups, independent (unrelated) t-test analysis was performed and the results of the analysis are given in Table 2.

Table 2. *Independent groups T-Test results for AST pre-test scores of experimental and control groups*

Group	N	x̄	SS	Sd	t	p
Experimental	30	5.00	2.03			
Control	30	5.70	1.70	58	1.45	.15

   As seen in Table 2, there was no significant difference between the AST pre-test scores of the control and experimental group students [t (58) = 1.45 p> .01]. Accordingly, it can be stated that experimental and control groups are equivalent in terms of AST scores.
   Second Sub-problem: Is there a significant difference between the pre-test and post-test score means of control and experimental group students?
   In order to answer the second sub-problem, the results of the normality test of the scores of the students in the experimental group were examined by the Shapiro-Wilk test, and the data were found to be in normal distribution [Statistics = .94; S.D. = 30; p = .1]. In our study, it can be said that the pre-test scores and post-test scores of the students in the experimental group showed normal distribution. Therefore, in order to determine a significant difference between AST pre-test and post-test scores of the students in the experimental and control groups, t-test analysis was performed for the related samples. The results of the analysis are given in Table 3 and Table 4.

Table 3. *AST experimental group pre-test and post-test mean scores, dependent sample T-Test results*

Measurement(AST)	N	x̄	S	sd	t	p
Pre-test	30	5.00	2.03	29	27.47	.00[*]
Post-test	30	18.60	2.96			

p <0.05*

A significant increase in academic success was found after the students' CBA applications [t (29) = 27.47 p <.01]. The mean academic success score of the students before the application was 5.00, but it increased to 18.60 after CBA applications. This finding demonstrates that CBA applications have a significant effect on students' academic success. In our study, as there was a normal distribution in the pre-test and post-test scores of the students in the control group (statistic = .96; SD = 30; p = .33), dependent t test was used to analyze if there was a significant difference between the control group students' pre-test and post-test scores. The results are shown in Table 4.

Table 4. *AST control group dependent sample T-Test results for pre-test and post-test mean score*

Measurement(AST)	N	x̄	S	sd	t	p
Pre-test	30	5.70	1.70	29	23.62	.00*
Post-test	30	12.90	1.51			

p <0.05*

A significant increase in students' academic success was found after present teaching practices [t (29) = 23.62 p <.01]. The arithmetic mean of the academic success scores of the students before the application increased to 5.70, but it increased to 12.90 after the traditional teaching practices. This finding indicates that the existing teaching practices increase students' academic success.

When the pre-test scores obtained from AST in Table 3 and Table 4 are examined, the arithmetic mean of the pre-test scores of the experimental group is 5.00 and the arithmetic mean of the pre-test scores of the control group is 5.70. The arithmetic mean of the post-test scores of the experimental group is 18.60 and the arithmetic mean of the post-test scores of the control group is 12.90. According to the pre-test scores of the groups, the increase in the post-test scores is higher.

Third sub-problem: Is there a significant difference between the post-test score means of the experimental group and post-test score means of the control group?

In order to determine the difference between the scores obtained from the post-test after AST, which was prepared in the experimental and control groups about the structure and properties of matter, the analysis of the covariance (ANCOVA) was performed. The results of the analysis are given in Table 5 and Table 6.

Table 5. *Mean Ratings of AST Post-Test Scores by Experiment and Control Groups*

Group	N	Mean	Adjusted Mean
Experimental	30	18.60	18.79
Control	30	12.90	12.70

Table 5 shows that if the post-test scores of the groups are placed in a high-to-low order according to the post-test scores, the students in the experimental group who have computer-based analogy practices have higher success scores. Table 6 shows the results of ANCOVA on whether the observed difference between the corrected post-test scores of the groups is significant.

Table 6. *ANCOVA results of the post-test points corrected by pre-test scores*

Source of Variance	Total of Squares	Sd	Squares Mean	F	p
Pre-test	65.98	1	65.98	14.70	.00*
Group	538.38	1	538.38	119.91	.00*
Error	255.92	57	4.49		
Total	809.25	59			

p<.01*

When Table 6 is examined, it can be seen that there is a significant difference according to p <.01 between the pre-test mean scores of the students and the mean scores of corrected success in the experimental and control groups F(1.57) = 119.91 according to ANCOVA results. In other words, the post-test scores are related to the group variable. According to the results of the Bonferroni test performed among the corrected success scores of the groups, the mean success score of the experimental group ($\bar{x}$ = 18.79) was higher than the mean of the control group ($\bar{x}$ = 12.70). According to the results, post-test success of the students in the experimental group where the computer-based analogy was applied for learning is higher than the post-test success of the traditional learning students in the control group. These results show that there is a significant difference between the experimental group in which computer-based analogy education is applied and the control group in which the traditional education method is used. This difference is in favor of the experimental group in terms of academic success. The findings of the study show that computer-based analogy is more effective on academic success than traditional education.

Fourth sub-problem: Is there a significant difference between the permanence test score means of the experimental group and permanence test score means of the control group?

In order to answer the fourth sub-problem, the results of the normality test of the scores obtained from the retention test of the students in the experimental and control groups were examined with the Shapiro-Wilk test. It was found that the data showed normal distribution in both groups (For the experimental group: statistics = .94; SD = 30; = .08 and for the control group: statistics = .930; SD = 30; p = .49). In order to compare the scores obtained from the retention test one month after the academic success test in the experimental and control groups, the mean scores of the retention test which were adjusted according to the post-test scores were determined. These values are presented in Table 7.

Table 7. *Mean and corrected mean of retention test scores*

Group	N	Mean	Corrected Mean
Experimental	30	17.33	14.71
Control	30	9.70	12.32

As shown in Table 7, the retention test scores of the students were calculated as 17.33 for the experimental group and 9.70 for the control group. The corrected means of the groups were 14.71 for the experimental group and 12.32 for the control group. It can be stated that the experimental group has a higher mean score than the control group according to the corrected mean scores. The results of ANCOVA on whether the difference between the mean scores of corrected permanence tests of the groups is significant are presented in Table 8.

Table 8. *ANCOVA results with respect to the group of retention test scores corrected by post-test scores*

Source of Variance	Total of Squares	Sd	Squares Mean	F	p
Pre-test	272.37	1	272.37	226.32	.00*
Group	34.09	1	34,09	28.32	.00*
Error	68.60	57	1.20		
Total	1214.98	59			

p<.01*

When Table 8 is examined, it is seen that there is a significant difference between the mean scores of the experimental and control groups' corrected stability test [F (1.57) = 34.09, p <0.01]. Therefore, according to the Bonferroni test results made between corrected stability tests scores of the groups, there is a significant difference in favor of the experimental group between the experimental group stability test mean score ($\bar{x}$ = 14.71) and the control group ($\bar{x}$ = 12.32).

These results show that there is a significant difference between the experimental group in which computer-based analogy education was applied and the control group where traditional education methods were applied in terms of the success of the science and technology course and the permanence of the information, in favor of the experimental group in both the final test and retention test. Findings show that computer-based analogy is more effective than traditional education in terms of retention.

b) Findings for Qualitative Research

Table 9 shows the themes and sub-themes determined according to the results of the content analysis conducted on the data obtained, as a result of the interview conducted with the computer-based analogy method of the students in the experimental group.

Table 9. *Themes and Sub-themes in the Analysis of Semi-Structured Interviews*

Themes	Sub-Themes
Benefit	Cognitive Contribution
	Affective Contribution
Reflective Application	Individual Mirroring
Mental Development	Creativity
Memory	Permanence
Teaching Events	Positive Feedback
	Negative feedback
Method And Technique	For Course
	For Students

When the findings obtained from the student opinions were evaluated, six themes related to CBA applications and nine sub-themes related to these themes were determined. The first question asked to the students is, "What are your thoughts about computer-based analogy practices in science and technology course?" Sub-themes, codes, and the repetition frequency of codes at the end of preliminary interviews under the main theme of benefit are recorded in Table 10.

Table 10. *Sub-Themes and Codes of the Theme of "Benefit"*

Themes	Sub-Themes	Codes	f
Benefit	Cognitive contribution	Facilitating association of information	2
		Opportunity for repeating topics	3
		Ensuring the persistence of information	11
		Providing learning without memorization	13
	Affective contribution	Helping the student become aware of his/her success	2
		Enjoying the lesson	7

As seen in Table 10, most of the students have expressed their opinions about the contributions of CBA applications to students. According to the answers of the students in the category of cognitive contribution of the CBA applications, the codes mostly expressed are providing learning without memorization (f = 13), ensuring the persistence of the information, the opportunity for repeating the topics, and facilitating the association of information (f = 2). According to Table 10, in effective contribution category, codes are formed as enjoying the lesson (f = 7) and helping students become aware of their success (f = 2). For example, (K; 3) said that: "*It helped me understand the subject better. It increased my performance and made me love the lesson more.*"

Second question is "Do you believe that writing analogy is beneficial? Please explain." According to the answers to this question, Table 11 was formed in terms of sub-theme, codes, and the repetition frequency of codes for the theme of "Reflective Application".

Table 11. *Sub-Themes and Codes of "Reflective Application"*

Theme	Sub-Theme	Codes	f
Reflective Application	Individual Mirroring	Concrete information	3
		Relationship with daily life	4
		Developing your imagination	4
		Facilitate learning	4
		Provide consolidation	12
		Providing persistence	16

All of the students in the study expressed that they liked the practices based on analogy as an answer to "Do you believe writing analogy is beneficial? Explain". In the process of writing analogies in science and technology courses, while providing persistence is the highest repeated code (f = 16) under individual reflection sub-theme, participants emphasized that facilitating learning, establishing relationship with daily life, enhancing imagination, and developing imagination are the other codes in order, and concretization (f = 3) is the lowest. For example, participant (K; 10) said that "*Because I embody the information, I can think more easily in daily life and I can make analogies.*"

Third question is "Did the practices made to you contribute to improve your creativity? How?" The answers to the said question are listed in Table 12 with the occurrence of sub themes, codes, and codes occurring under the main theme of mental development.

Table 12. *Sub-Themes and Codes of "Mental Development" Theme*

Theme	Sub-Themes	Codes	f
Mental Development	Creativity	Increasing imagination	6
		Associating with daily life	12
		Organizing materials	14

When Table 12 is examined, it is observed that most of the students show their opinions on CBA applications' usefulness for creativity. According to CBA applications' contribution to creativity in science and technology courses, while the highest repeated code is organizing materials (f=14) under the sub-theme of creativity, the lowest repeated code is increasing imagination (f=6).

Some of the answers given by the students in the interview form are given below:

(K;8): *"I can exemplify myself by designing and thinking, and it developed my creativity."*

(K;2): *"I compare the concepts of the subject with many different things, which increases my creativity."*

Table 13 shows the frequency of repetition of sub-themes, codes, and codes that occur at the end of the preliminary interviews under the main theme of memory with the answers to Question 4.

Table 13. *Sub-themes and codes of "memory" theme*

Theme	Sub-Themes	Codes	f
Memory	Permanence	With models and games	2
		With a variety of activities	5
		Through analogies	14
		Visualization	15

"Do you believe how it contributes to the persistence of knowledge when the course is taught with computer-based analogy? Explain." When the answers to this question are examined, it is noticed that they generally reveal their opinions about the fact that CBA applications provide permanent information. In the science and technology courses, the highest repeated code is visualization (f = 15) in terms of permanence sub-theme, and the lowest repeated code is models (f = 2). For example, participant (K; 4) said that *"Simulation increases my imagination. It makes the information permanent."*

Table 14 shows the frequency of repetition of sub-themes, codes, and codes at the end of preliminary interviews under the main theme of the teaching activities in accordance with the answers given by the students to Question 5.

Table 14. *Sub-Themes and Codes of "Teaching Activities" Theme*

Theme	Sub-Themes	Codes	f
Teaching Activities	Positive Feedback	Provide consolidation	2
		Increase creativity	6
		Active participation	6
		Increase success	9
		Facilitate learning	11
		Make it fun	13
		Simplify remembering	20
	Negative Feedback	Provide false learning	1

When Table 14 is examined, most of the opinions given to the question "What are the positive and negative aspects of the learning in the science and technology course when the CBA practices are done?" are that there are positive aspects of computer-based analogy applications. The students' perceptions about the teaching and learning activities were grouped by the researchers into two categories: "positive opinion" and "negative opinion". When the positive opinions of the program are examined in accordance with the answers of the students, the most repeated code (f = 20) is to simplify remembering, and the others are to ensure fun, to facilitate learning, to increase success, to increase creativity, and to ensure

active participation. To provide consolidation is the lowest repeated code (f = 2). As for the negative opinions, a student complained that it might cause false learning.

For example, (K; 13) said that "*When we study with CBA, the lesson is fun, what we learn is more permanent, but sometimes the practices in CBA-based courses have confused me.*"

The frequency of repetition of sub-themes, codes, and codes at the end of the preliminary interviews under the method and technical main theme created in line with the answers to the question 6, "Do you want to learn the other subjects of science and technology lesson in a similar way? Why?" is shown in Table 15.

Table 15. Sub-Themes and Codes of "Method and Technique" Theme

Theme	Sub-Themes	Codes	f
Method and Technique	For Courses	Because it provides repetition of topics	2
		Because it saves the lesson from monotony	10
		Because it includes technology size	20
		Because it increases curiosity and interest	2
	For Students	Because it ensures the concretization of information	
		Creativity	4
		Because it provides active participation	
		Because it provides meaningful and permanent learning	0

As shown in Table 15, all of the students stated that they prefer to use CBA applications in other science subjects. In accordance with the answers of the students to the question, they were grouped under two categories: "for the course" and "for the student".

According to the "for the course" sub-theme of the method and technical theme, it was stated that the lesson was recovered from the monotony, provided the repetition of the subjects, and the technology dimension took place. According to the "for the students" sub-theme, the concretization of information provided meaningful and permanent learning, increased curiosity and interest, improved creativity, and enabled active participation of students. For example, participant (K; 14) said, "*Yes. Because the course is more fluent and the course is more enjoyable, so it is easier to understand the subject.*"

DISCUSSION and RESULTS

a) Academic Success Level

Table 3 and Table 4 show the effect of the method on the academic success of the students on "Structure and Properties of Matter". The mean success score ($\bar{x}$= 18.60) of the experimental group was higher than the mean score of the control group ($\bar{x}$= 12.90). According to the results of this study, the CBA learning post-test scores of the students in the experimental group were higher than the post-test scores of the students in the control group who study with the present program. When Table 6 is examined, it is seen that there is a significant difference between the experimental group students studying with CBA applications and the mean of the academic success points corrected according to the pre-test mean scores of the control group students who study with the present program ($F_{(1, 57)}$ = 119.91, $p < .01$). The findings of the study show that CBA learning is more effective on students' academic success than the present program. Similar findings were obtained by Şahin, Akbulut, and Çepni (2012) in their work on animation, worksheets, and analogies developed on the topic "I am exploring the pressure". This result is supported by many research conducted in different disciplines and CBA applications in the literature (Akçay, Tüysüz and Feyzioğlu, 2008; Akpınar, 2005; Atav, Erdem, Yilmaz and Gucum, 2004;

Aykutlu and Sen, 2011; Yellow and Harwanto, 2015; Günel, Kabataş Memiş and Büyükkasap, 2009; Güven and Sülün, 2012; Karamustafaoğlu, Aydın and Özmen, 2005; Özmen and Kolomuç, 2004).

In this study, the reasons for the fact that the analogy method supported by CBA is more effective than the applications in the present program are CBA's use of facilities, such as image, text, sound, and animation, transferring instructional content and activities through computer, concretizing the subject by using computer-based simulation and models, making it easier for the student to retain the information, increasing the level of motivation of the students, having fun and learning their own ideas, and enabling students to keep active by providing high motivation skills.

b) Permanence

In the study conducted to determine whether the knowledge learned about "Structure and Properties of Matter" is permanent or not, according to the results of the analysis given in Table 7, the mean scores of the students' corrected retention test are ($\bar{x}$=17.33) for the experimental group and ($\bar{x}$=9.70) for the control group. In this case, it can be stated that the experimental group, in which the science and technology course is taught with the CBA applications, has a higher mean score than the control group taught with the present program. In the second stage, according to Table 8 covariance analysis, there is a significant difference between the mean scores of the experimental and control groups' corrected retention test according to the results of the test scores of the students who have different scores as per the post-test scores in different groups [$F_{(1,57)} = 34.09$, $p < .01$]. In other words, it has played a positive role in ensuring the permanence of the students' knowledge of the learning performed with the CBA applications used.

The findings of this study and the findings of the studies in the field literature are in parallel. Demirci Güler (2007), in his study on the use of analogies in science and technology course, indicates that the courses affect the students' success and the persistence of their knowledge. Zembat, Şahin, Çağlak, and Polat (1999) found that analogy training facilitated the acquisition of abstract concepts and increased the permanence of learning. As for the study conducted by Kara, Kahraman, and Baştürk (2008), in order to teach the subjects of physics in science course from seventh grade and to determine whether computer-based education has a lasting effect on students' academic success, the last test was applied to both groups after five months. There was a significant difference in favor of the experimental group among the mean of the subject test scores of science lesson in the experimental and control groups. Similar results can be seen in the study of the immune system by Bilaloğlu (2006).

c) Views for Computer-Based Analogy Applications

In this section, the opinions of the students in the experimental group about CBA applications were taken. As a result of these evaluations, the analogies helped the students to listen effectively, better understand the subject, learn the lesson by communicating with their friends, and enjoy the lesson by living with the materials other than the textbook. Similarly, in the study conducted by Bilgin and Geban (2001) where high school second-class students learned the subject of chemical balance, the students understood that they learned the concepts better. Gentner and Holyoak (1997) state that students are very effective in learning the concepts of science, which are abstract for them and are not included in their lives. As for the study conducted by Ören et al. (2011), it was found that in some stages of the interrogative approach cycle, analogy technique is included. In this study, a guideline material on "matter and change" learning was developed in science and technology course by using research-

based learning approach and analogy technique. Widespread use of developed materials in varying teaching programs was proposed. Demir, Önen and Şahin (2011) support our study on the information classified in the studies analyzing teacher candidates' views on the use of analogy. For example, the majority of teacher candidates who stated that they would use analogies in their future occupations said that analogies can be used as an effective teaching material for reasons of "providing permanence", "providing visuality", "making contact with daily life", and "facilitating learning".

The analogies used during the application facilitated the students' recall. The researcher observed that the students' interest in the course increased during and after the practice. According to the study of Ekici, Ekici, and Aydin (2007), analogies can be used to keep the concepts more permanent by stimulating the imagination of the students and foregrounding visualization of them in the second stage of primary education. Trey and Khan (2008) found that computer-based analogies were more effective than observations in the visual analogies of students.

According to the opinions taken at the end of CBA applications, it was determined that the positive effect of the analogies on developing positive attitudes toward the course provided both success and creativity. Students' creative thinking skills may be increased due to the opportunities such as discussion with friends using the analogy-supported method, sharing ideas within the group, and guiding the lesson according to their own decisions. The active participation of all the students in the course and the lesson they prepared with the materials motivated them, and through this, they learned by having fun.

These findings are consistent with the present literature. Chiu and Lin, (2005), Kesercioglu et al., (2004), examined the study. It was found that the applied analogy method was very successful in arousing students' curiosity and getting more pleasure from the course. Kaptan and Arslan (2002) compared the effect of the question-answer technique and analogy on the students' successes and their views on science. Analogy enables students to develop their scientific thinking, problem-solving skills, and creativity while providing active participation in educational environment (Kaptan & Arslan, 2002). Castillo (1998) found that analogy is an effective method in expanding their creativity. The study of Uğur, Dilber, Şenpolat, and Düzgün (2012) showed that the analogy method increased students' success and attitudes toward physics course.

However, CBA practices lead to misinformation when students fail to perceive target and concept association. This has led to negative views on the application based on the computer-based analogy method. When we look at the literature on the advantages and disadvantages of analogies, it is seen that the advantages and disadvantages of Duit (1991) and the advantages obtained from students' views match. It can also be seen in the studies mentioned in the literature that the students help other students to embody abstract concepts in science courses.

As a result, CBA practices increased the motivation of the students by making an abstract subject concrete in the students' thoughts and concretely developing the idea that they can understand in their minds. In this way, it is said to have an effect on the realization of fun and creativity.

Suggestions

Teachers should ensure that students participate actively in the lessons. Meanwhile, visual materials such as computer-based analogies can be used to make meaningful learning possible by taking students away from memorization. In this respect, the material-producing organizations and the Centre for Educational Tools may make analogies by preparing alternative activities related to the subjects in the curriculum when preparing the course materials.

This research is limited to the teaching of "Elements and Symbols", "Structure of the Atom", "Sequence of Electrolyte and Chemical Properties" and "Chemical Bonding" in the seven-week period of a school year and the seventh-grade of secondary education. Similar experimental studies should be conducted on a longer term and on different and more comprehensive subjects, and the results should be compared. Considering the importance of analogies in concept teaching, upper cognition thinking skills and conceptual change can be questioned through the products that students can produce.

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APPENDIXS

Appendix-1: Article Difficulty, Substance Discrimination and Standard Deviation Values Related to Academic Success Test

Item No	Item Difficulty Index (pj)	Item Discrimination Index (Rjx)	Standard Deviation (Sj)
q1	.59	.67	.49
q2	.80	.41	.37
q3	.67	.52	.47
q4	.76	.41	.43
q5	.83	.33	.40
q6	.81	.37	.45
q7	.72	.56	.42
q8	.81	.30	.34
q9	.65	.63	.45
q10	.80	.41	.36
q11	.52	.44	.50
q12	.69	.48	.47
q13	.76	.33	42
q14	.61	.48	.47
q15	.78	.44	.39
q16	.66	.52	.47
q17	.76	.41	.42
q18	.69	.44	.33
q19	.81	.37	.38
q20	.57	.48	.49
q21	.74	.44	.43
q22	.74	.44	.42
q23	.46	.56	.50
q24	.69	.41	.49
q25	.81	.37	.37
q26	.65	.56	.49

Appendix -2: Element And Symbols, Presentations, And Analogy Examples