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EFFECTS OF THE CONTEXT-BASED APPROACH ON STUDENTS' CONCEPTUAL UNDERSTANDING: "THE UMBRA, THE SOLAR ECLIPSE AND THE LUNAR ECLIPSE"

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Abstract. *The purpose of this study was to explore the effects of context-based learning approach (CBLA) on 5th grade students' misconceptions about 'the umbra, solar and lunar eclipses'. In this study, a quasi-experimental methodology pre-test and post-test design was utilized with control and experimental groups. The study was conducted with 48 5th grade students (aged 10 to 11 years). For the experimental group, the topics were explained using the CBLA while for the control group the 5E teaching model of the constructivist approach was used. For data collection, a two-tier conceptual test and a semi-structured interview were used. Study results indicated that the learning environment designed in accordance with the CBLA was a superior instructional tool than the 5E teaching model learning environment in terms of students' conceptual learning performance and eliminating students' misconceptions. In addition, CBLA helped students to link between the scientific concepts and the context related to the daily life.*

Key words: *context-based learning approach, conceptual understanding, umbra, lunar and solar eclipses.*

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Introduction

Science education is extremely important in today's world, where scientific knowledge, rapid technological developments and scientific technologies play a large role in our daily lives. For this reason, developed countries conduct studies in order to improve the quality of science education. With this aim in mind, students are expected to develop their own conceptual understanding, conduct experiments, observe, learn by doing, and contribute to their own education by drawing on their affective abilities along with cognitive and psycho-motor skills (Baird, Fensham, Gunstone & White, 1991; Garnett, Garnett & Hackling, 1995). Students' prior conceptual understandings may have an inhibitory effect on learning new topics (Garnett et al., 1995; Entwistle & Ramsden, 2015). Thus, students who are without misconceptions, erroneous conceptions will achieve more positive outcomes in learning other topics.

Novak (1988) and Yağbasan and Gülçiçek (2003) have defined 'misconception' as 'an individual's understanding of a concept showing significant difference from universally accepted scientific meaning'. Inaccurate information and experiences can prevent new information from being assimilated in an accurate way, promote the continuation of alternative understandings, prepare the ground for new misconceptions and undermine students' ability to interpret data. As conceptions in science are usually abstract, students often cannot visualize these concepts and thus develop alternative and erroneous conceptions (Harrison & Treagust, 2000). To prevent this, science instructors require studies examining ways to effectively inculcate accurate knowledge and to minimize misconceptions (Karslı & Çalık, 2012). So, it is a need that use of modern learning approaches improving their conceptual understanding and associating their daily lives with science lessons. Demonstrating the relevance of science to everyday life is as important in this as the positive interaction between students and teachers. The biggest obstacle for educational activities is how to motivate and keep students – and teachers – interested. One approach developed to eliminate this obstacle is the 'Context-Based Learning Approach (CBLA)' (Glynn & Koballa, 2005; Bennett & Lubben, 2006). In recent years, it has been used widely in many countries in the world to improve the quality of education. It is recommended to use teaching programs that are designed within the framework of the CBLA, and which make connections with real life, make subjects interesting, provide meaningful learning, provide active participation of students in class, and enable the information to be formed in students' minds (Bulte, Westbroek, Jong & Pilot, 2006; Gilbert, 2006; Gilbert, Bulte & Pilot, 2011). Considerable efforts have been put on reconsiderations in curricula with many projects about CBLA. For example: The Salters Approach and SLIP (Supported Learning in Physics Project) in the UK, Piko (Physik im Kontext) in Germany, PLON (Dutch Physics Curriculum Development Project and NiNa) in the Netherlands (Bennett, Hogarth & Lubben, 2003), Salters Advanced Chemistry in the UK (Bennett & Lubben, 2006), Chemistry in Context in the USA (Schwartz, 2006) and the Context-concept Approach in the Netherlands (Bulte et al., 2006). In addition, the cognitive and constructivist learning theories constitute the foundation of the CBLA (Ingram, 2003; Glynn & Koballa, 2005). Because constructivism asserted that learning can occur when the students relate new knowledge with their pre-existing knowledge, similarly CBLA suggests using familiar and suitable contexts from daily life in the establishing relations (Whitelegg & Parry, 1999; Hoffman & Demuth, 2007; Ültay, 2015). CBLA is one of the approaches that allow learning to take place with real and related context, and finding the answers to the questions as 'How will this information be useful for me?' and 'Why do you need to know?'. With CBLA, the students are presented with a scientific content in an atmosphere which they feel the need to learn new knowledge (Pilot & Bulte, 2006; Demircioğlu, Demircioğlu & Calık, 2009).

CBLA helps increase students' understanding by transforming lessons so that they are in a more engaging, interesting and fun way used as a strategy for research based of the daily life problems' solutions (Gilbert et al., 2011; Acar & Yaman, 2011; Glynn & Koballa, 2005; Demircioğlu et al., 2009). The CBLA provides an increase in students' success rates (e.g. King & Ritchie, 2013; Demircioğlu, Dinç & Çalık, 2013; Çiğdemoğlu & Geban, 2015; Broman, Bernholt & Parchmann, 2015), and is effective in developing a positive attitude towards science and increasing motivation among students (e.g. Campbell, Lubben & Dlamini, 2000; Birchinall, 2012; Belt, Leisvik, Hyde & Overton, 2005; Taasoobshirazi, 2007; Bennett, Grasel, Parchmann & Waddington, 2005; Hırça, 2012). Moreover, it facilitates learning by helping the learners associate the abstract topics or concepts to daily experiences (e.g. Campbell et al., 2000; Ingram, 2003; Gilbert et al., 2011;) and develops a scientific understanding in the learners (e.g. Bennett et al., 2005; Çiğdemoğlu & Geban, 2015). The reason the CBLA was used in this research is to enable students to perceive events that occur in their daily lives in a different way and to associate these events with their science lessons.

In science education, there are some studies that used the CBLA in the "respiration and energy" (Whitelegg & Parry, 1999; Yaman, 2009), "impulse, momentum and collisions" (Ültay, 2014), "waves" (Değermenci, 2009), "electromagnetic induction" (Yayla, 2010), "heat-temperature" (Aktaş, 2013), "work, forces, energy, the 'Pascal principle', rain formation and how ships float" (Hırça, 2012) and "physical and chemical change" (Demircioğlu et al., 2013). As seen in these studies, a research used the CBLA on the astronomy concepts was not found. National Research Council, (1996) recommends that fundamental astronomy concepts be included as an important part of every child's education. Among these are the Earth's spherical shape and gravity (Agan & Sneider, 2004), phases of the Moon, and solar and lunar eclipses. Similarly, American Association for the Advancement of Science, (1993) also recommend that students become familiar with the lunar cycle of phases in the elementary years, but that explanations of these phenomena in terms of mental models should wait until middle school (Kavanagh, Agan & Sneider, 2005). The astronomy topics are more interesting than the other science subjects for elementary school students (Dede, 2006; Şahin, Arıkurt & Durukan, 2015). At the same time, students are difficult to understand the complex concepts of astronomy lesson (Dunlop, 2000). Students with misconception about these topics (the umbra, solar eclipse and lunar eclipse) find it difficult to learn further topics such as the solar system, astronomy and studies of space (National Research Council, 1996; Yair, 2001). In the science curricula, 'the umbra, solar eclipse and lunar eclipse' concepts are being taught together, because solar and lunar eclipses describe with the umbra formations (Ministry of National Education [MNE], 2013). So students can better configure the causes of solar and lunar eclipses. 'The umbra, solar eclipse and lunar eclipse' concepts thus are the cognitive keys that students need to be able to understand and discover fundamental principles

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and astronomy. It is obvious that the umbra is one of the most fundamental topics in astronomy because the concepts in the topic are associated with the day–night cycle, seasonal changes, eclipses, phases of the Moon, the tilt of the Earth, the tides, the solar and tides energy and three-dimensional concepts about astronomy. In order to comprehend these concepts, students should fully understand the key concepts such as 'the umbra, solar eclipse and lunar eclipse'.

In the science education, there have been a lot of studies to determine students' understanding, eliminate the misconceptions about the umbra, eclipses and phases of the Moon. It was reported that students may have some misconceptions of these topics, developed before entering the educational environment (e.g. Rider, 2002; Barnett & Morran, 2002; Türk, Kalkan, Bolat, Akdemir, Karakoç & Kalkan, 2012; İyibil, Kurnaz & Gultekin, 2012). For example, Comins (2001) found that many of his college students confuse the explanations for phases and eclipse of the Moon, believing that lunar phases are caused by the shadow of the Earth. Stahly, Krockover and Shepardson (1999) identified in the third graders and Dai (1991) identified in the fifth and sixth graders the misconceptions about the moon and eclipses. These included misconceptions about the time of moonrise; mixing solar eclipse and lunar eclipse; position of the Moon; lunar and Earth phases; confusing the moon's position at full moon with its lunar eclipse position and the bird's-eye view (the model of the Earth-Moon-Sun system). Keating, Barnett, Barab and Hay (2002) aimed at investigating the effect of 3D computer modelling on teaching three foundational astronomical phenomena: the causes of lunar and solar eclipses, the causes of the Moon's phases, and the reasons for the Earth's seasons. They determined that the experimental group in which the 3D computer modelling was used as a teaching method was found more successful than the control group. Abell, Martini and George (2001) aimed at investigating the effect of constructivist learning approach on teaching Moon phases and eclipse. They determined that constructivist learning approach helps students understand these concepts. Gazit, Yair and Chen, (2005) examined the effect of using a virtual solar system on conceptual development of the basic astronomical phenomena. And they found that all participants used the virtual solar system as a visual thinking tool and developed a scientific understanding of the causes of the day–night phenomena. Meanwhile, they have focused on diverse samples: elementary student teacher (Abell et al., 2001), undergraduate university students (Keating et al., 2002), high school students (Gazit et al., 2005). To sum up, conceptual change studies have generally concentrated on either high school or undergraduate students. The misconceptions about 'the umbra, the solar eclipse and the lunar eclipse' can persist into adulthood. Addressing these misconception understandings at an early stage will help students to learn more advanced topics more effectively. A search of the literature found no prior research both examining the utilization of the CBLA and focusing elementary or secondary school students for the topics of 'the umbra, the solar eclipse and the lunar eclipse'. It is generally not possible to find a course book or curriculum document that incorporates CBLA for all topics of study at school. To diminish such lack, using the materials designed in accordance with the CBLA may help students develop a better conceptual understanding because this process gives an opportunity for students to expose to an enriched learning environment in a more engaging, interesting and fun way used as a strategy for research based on the daily life problem solutions. In addition, it is our belief that present research will increase CBLA's implementation fields in addition to shed light to future researches on the same subject.

Purpose of the Research

The purpose of this research was to explore the effects of CBLA on 5th grade students' misconceptions about 'the umbra, the solar and the lunar eclipses'. Following are the research questions: (1) Does the CBLA cause a statistically significant difference in students' 'the umbra, the solar eclipse and the lunar eclipse' concepts? (2) How do the students' conceptual understandings of 'the umbra, the solar and the lunar eclipses' change with the CBLA?

Methodology of Research

General Background and Sample

To address the research questions, the present study used a quasi-experimental methodology pre-test and post-test design with one experimental group with the CBLA and one control group with the constructivist approach. This design is frequently used in studies of the desired collection of data on the effectiveness of an experimental intervention (Çepni, 2014).

The sample of this study consisted of 48 5th grade students (aged 10 to 11 years) from two different classes in a secondary school in the city of Giresun in Turkey. One of the classes was randomly assigned as the control group and the other was assigned as the experimental group in this study. There were 24 students in the experimental group and 24 in the control group. Students learned umbra concept in the 4th grade for the first time in basic level. In the 5th grade, students are taught 'umbra, solar and lunar eclipses' concepts together. This means that the students do not take any course concerning these concepts at this level in detail.

Table 1. Demographic characteristics of students who participated in the study.

Group	Female	Male	Total
Control	11	13	24
Experimental	10	14	24
Total	21	27	48

Instrument

For data collection, a two-tier 'umbra, solar and lunar eclipses' conceptual test (CT) developed by the authors was used. The two-tier CT consisted of 10 questions in total and both sections consisted of multiple-choice questions. The instrument was designed based on related literature and students' reported misconceptions. In the two-tier tests, each question's first tier with one correct answer and distracters including misconceptions derived from related literature, concentrates on the knowledge domain, whereas the other tier relates to comprehension. In the second tier, students were asked to specify their reason for selecting the relevant answer in the first section. In this way, the risk of receiving misleading, 'luck-based' correct answers from the students was decreased and the reliability and validity of the test itself were increased (Chandrasegaran, Treagust & Mocerino, 2007). To probe students' conceptions and/ or misconceptions, such questions are generally exploited (Treagust & Chandrasegaran, 2007).

The concepts have been identified from the science curriculum (MNE, 2013). In the curriculum, the learning outcomes of the lesson about this subject consist of three parts: (1) the formation of the umbra, (2) associating with the formation of full umbra the sun and lunar eclipses without entering the penumbra topic and (3) factors affecting the size of the umbra. During the preparation of the questions for the CT, the relevant science curriculum was examined, along with studies in the literature (MNE, 2013). Two questions in the test were related to the lunar eclipse, three questions were related to the solar eclipse, two questions were related to umbra formation and three questions were related to factors affecting the size of the umbra by considering of learning outcomes from the curriculum. In this way, all concepts are tested with more than two questions. In order to gain evidence on the validity of the test's design and content, the two-tier CT was presented to four experts for approval: Two science instructors and two science and technology teachers. Following their opinions and feedback, the test was finalized. Also, 6 students, other than the sample, were asked to read the CT and let the authors know about any unclear or confusing points. Afterwards, some minor revisions were made to the items in the CT. Then, the CT was pilot tested with 95 5th year students, apart from the sample. For this reliability, Cronbach alfa coefficient was calculated as 0.91.

A sample question from the two-tier CT developed by the authors is shown in Figure 1

ISSN 1648–3898

a) How does the shadow of an object change if the object is moved away from the light source?

1 2

A) Grows B) Doesn't change C) Decreases D) Its shape changes

b) Why did you choose that particular answer? Please explain.

A) The shadow doesn't change because the light source doesn't change.

B) Objects get smaller as they move away so the shadow shrinks.

C) As light spreads to more areas as the object is moved away, the shadow also grows.

D) The shadow changes to a different shape because the object is moved away.

E) Other……………………………………

Figure 1: A sample question from the two-stage CT.

In order to evaluate students' misconceptions of the topics discussed and to mitigate the effect of 'luck-based success', a total of 6 students from the experimental and control groups who had shown high, moderate and low levels of success in the pre-tests were also given a semi-structured interview with 7 questions regarding the topics discussed. The semi-structured interviews were carried out by the second author and each interview lasted almost 30-40 minutes. The interview questions about conceptions are shown in Table 2.

Table 2. Semi-structured interview questions about conceptions.

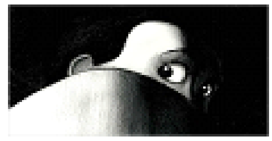
1- Can you explain when the shadow shrinks? Can you demonstrate that with the materials I have given you?
2-We are playing a game with friends. We have a flashlight. Can you tell me how to hold the flashlight so that our shadows are bigger? Can you demonstrate that for me?
3-Can you explain the reason for the formation of a solar eclipse?
4-What are the positions of the Earth, Sun and Moon during a solar eclipse? Can you draw this?
5-Can you explain the reason for the formation of a lunar eclipse?
6-What are the positions of the Earth, Sun and Moon during a lunar eclipse? Can you draw this?
7-Can you demonstrate a lunar and solar eclipse with the materials I have given you?

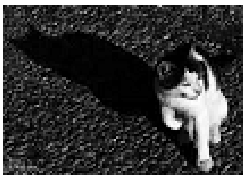
Teaching Materials and Implementation

To develop material based on the CBLA, the authors examined a number of related resources, such as grade 5 science and technology textbooks, publications of the Salters Approach and SLIP (Supported Learning in Physics Project) in the UK, Piko (Physik im Kontext) in Germany, grade 5 science curricula and prior studies in the literature on the CBLA (Whitelegg & Parry, 1999; Choi & Johnson, 2005; Yaman, 2009; Ültay, 2014). Teaching materials were developed and the stories were written by using a context named 'Buse's Fear' by the authors. The teaching materials were examined by two science instructors (whose expertise lies in the CBLA), and two science and technology teachers for their approval, ensuring the validity of the materials' content. It is found that the teaching materials are appropriate to the CBLA, the content and level students by experts' common opinion. Then, this version of the teaching material was pilot with 6 fifth grade students, apart from the sample. Students were asked to read the teaching material and let the authors know about any unclear or confusing points. A section of the teaching material was developed by the authors is given Figure 2.

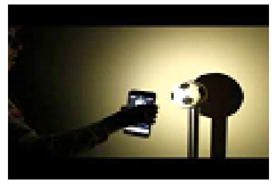
ISSN 1648–3898

Buse's Fear



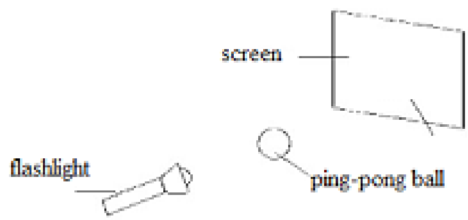


Buse was a girl who is afraid of the dark and 10-year-old. Buse could not prevent the horror from inside. Although 10-year-old, she has turned on the lights permanently before falling asleep. After asleep, her mother turned off all the lights. But she wanted to confront her fears. One day, while returning from school in the afternoon, she realized that big of a cat's shadow. She was very shocked. She constantly asked herself: "How could a tiny cat's shadow so big?" and she asked her mother the reason of this condition. Her mother said let's play a game. They began to play games together. They turned off the room's lights taking the flashlight and toy ball. They operate the flashlight and headed flashlight towards the toy ball. She realized that how large the shadow of the toy ball on the wall. Her mother had left her alone in the room. She followed the shadows formed in the wall of the room with various objects. Buse was a lot of fun. Despite the long period of time, Buse has remained in the dark alone. She was beginning to overcome her fear of the dark. Buse also showed to their classmates her experience in the next science course.



What was Buse afraid of?
Are any of you afraid of the dark?
How can the shadow of a tiny cat be this big?

Let's play Buse's game to face your fears of the dark:



1. How does a shadow? Let's see.

2. What happened when the ping-pong ball closer to the flashlight? Draw the shadow formation.
3. What happened when the ping-pong ball move away from flashlight? Draw the shadow formation.
4. What happened when the ping-pong ball closer to the screen? Draw the shadow formation.
5. What happened when the ping-pong ball move away from the screen? Draw the shadow formation.

In which situations did the shadow grow?..

In which situations did the shadow shrink?..

Figure 2: An example story used in the experimental group.

ISSN 1648–3898

An example lesson outline for the experimental group is given in Table 3.

Table 3. The role of the teacher and student in administering teaching materials developed in accordance with the CBLA.

	Teacher's Role	Student's Role
Lesson One	*The teacher starts the lesson with a story named 'Buse's Fear'. *The teacher asks students to read the story and thoroughly introduces the concept to them. *The teacher asks students questions like "What was Buse afraid of?", "Are any of you afraid of the dark?"; "How can the shadow of a tiny cat be this big?" and familiarizes the students with the context. *The teacher gives worksheets to the students and waits for them to carry out experiments with these materials. *The teacher conducts the 'sundial' activity, establishing the relationship of the topic to real life. *The teacher asks the following questions about the topic: "In which situations did the shadow grow?";"In which situations did the shadow shrink?"	*Listens to the story carefully and familiarizes him/herself with the context. Tries to answer questions related to the story. *Conducts experiments with given materials. *Records the data he/she obtains from the experiment onto the worksheet provided. *Makes observations by participating in activities. *Tries to give correct answers to questions asked by the teacher.

Firstly, the two-tier CT was administered to the students as a pre-test before beginning of the implementation. Then, the 5th grade students were separated to small groups of 3 or 4 students. The separate lesson plans were prepared and used in both groups about the topics mentioned above. The lesson plans in the experimental group were based on REACT strategy including relating, experiencing, applying, cooperating and transferring steps as used in the CBLA. The lesson plans in the control group were based on 5E model including enter, explore, explain, elaboration and evaluation steps as used in a constructivist approach. A 4-year-experienced science teacher one of the authors taught the 'umbra, solar eclipse and lunar eclipse' concepts during 6 lesson hours (6*40 min.) in both groups. In the lessons using the CBLA, 'the umbra, the solar eclipse and the lunar eclipse' concepts were explained by using a context named 'Buse's Fear'. To teach this, worksheets in accordance with the CBLA were prepared and given to students. After the implementation, the two-tier CT was administered to the students as a post-test. Then, the semi-structured interviews were carried out.

Data Analysis

The first and second stages (sections) of the two-tier CT were scored separately and scores were aggregated. In analysing the items, Karslı and Çalık (2012) criteria were used to analyse students' responses. In the first section of the test, if a student had selected the correct answer it was coded as Correct Option (CO). If an incorrect answer was selected, it was coded as Incorrect Option (IO), and if the answer was blank it was coded as (B). For the second stage, if the student's explanatory answer contained entirely scientific and accurate information, it was coded as Correct Explanation (CE). If the answer was related to the question but not accurately enough, it was coded as Partially Correct Explanation (PCE). If the answer contained scientifically inaccurate information it was coded as Explanation with Misconception (EWM), and if the answer contained unrelated information or was left blank, it was coded as (B). The evaluation criteria and scores for the two-tier CT evaluation are shown in Table 4.

Table 4. Evaluation criteria and scores for evaluation of the two-tier CT.

Categories of Multiple-Choice Questions	Categories for Explanatory Questions	Abbreviation	Total Score
Correct Option	Correct Explanation	CO-CE	10
Correct Option	Partially Correct Explanation	CO-PCE	9
Incorrect Option	Correct Explanation	IO-CE	8
Blank	Correct Explanation	B-CE	7
Incorrect Option	Partially Correct Explanation	IO-PCE	6

Categories of Multiple-Choice Questions	Categories for Explanatory Questions	Abbreviation	Total Score
Correct Option	Explanation with Misconception /Incorrect Explanation	CO-EWM	5
Correct Option	Blank	CO-B	4
Incorrect Option	Explanation with Misconception /Incorrect Explanation	IO-EWM	3
Blank	Explanation with Misconception /Incorrect Explanation	B-EWM	2
Incorrect Option	Blank	IO-B	1
Blank	Blank	B-B	0

As seen in Table 4, the maximum score for the two-tier CT is 100 (10 points for each answer). Normal distribution is checked with Shapiro Wilks test in order to decide which test should be used in data analysis because of the small sample size of 50 people (Büyüköztürk, 2007). The data showed no normal distribution. It is proposed that the use of non-parametric statistical test is given that they are less restrictive than parametric ones and they can be used over small size samples of results (Garcia, Molina, Lozano & Herrera, 2009). In order to compare pre-test and post-test scores of students in the experimental and control groups, non-parametric statistical techniques were used. Differences in pre-test and post-test scores were examined by conventional statistical means using the Mann-Whitney U-test for independent samples, the Wilcoxon Signed Rank test for dependent samples respectively and a Windows version of Statistical Package for the Social Sciences (SPSS 16.0).

The privacy of students interviewed is extremely important (Ataseven, 2012). For this reason, students in the control group were coded as C1, C2 and C3, while students in the experimental group were coded as E1, E2 and E3. The data from the semi-structured interviews were analysed in terms of content (Yıldırım & Şimşek, 2013). For the content analysis, the recorded audio data were first transcribed and then converted to written form. This data was filtered and simplified, eliminating unrelated speech data. On the basis of the interview questions used in this study, portions which constituted a meaningful section as a whole (data) were coded by researchers. Specific themes grouping these coded sections into certain categories were developed. The data were revised in accordance with these determined themes. In order to ensure the reliability of the data and to provide first-hand data to the reader, direct quotations from the students were then added. Finally, the categories into which the data had been organized and defined were examined and the results were interpreted and evaluated.

Results of Research

Results from the Two-Tier CT

The Mann-Whitney U-pre-test results for the two-tier CT scores of students in the control and experimental groups are shown in Table 5.

Table 5. Mann-Whitney U pre-test scores for two-tier CT of students in the control and experimental groups.

Groups	N	Rank average	Rank total	U	p
Control	24	22.94	670.50	205,500	0.08
Experimental	24	20.06	505.50		

Table 5 shows that there is no statistically significant difference between the two-tier CT pre-test scores ($U=205.500$, $p> .05$) of students in the control and experimental groups. When rank averages are examined, it can be seen that the two-tier CT pre-test scores of control group students are higher than those of students in the experimental group.

The Mann-Whitney U-post-test results for the two-tier CT scores of students in the control and experimental groups are shown in Table 6.

ISSN 1648–3898

Table 6. Mann-Whitney U post-test scores for two-tier CT of students in the control and experimental groups.

Groups	N	Rank average	Rank total	U	p
Control	24	25.88	381.00	81.00	0.001
Experimental	24	33.12	795.00		

Table 6 shows that there is a statistically significant difference between post-test results of students in the control and experimental groups (U=81.00, p< .05) in favour of the experimental group. When rank averages are examined, it can be seen that the two-tier CT post-test scores of the experimental group students are higher than those of students in the control group.

The Wilcoxon Signed Rank Test results for determining whether the two-tier CT pre-test and post-test scores of the students in the control and experimental groups show a statistically significant difference are shown in Table 7.

Table 7. Wilcoxon Signed Rank Test results for two-tier CT pre-test and post-test scores of students in the control and experimental groups.

Group	Post-test-Pre-test	N	Rank average	Rank total	z	p
Control	Negative Rank	4	7.50	37.50	4.287*	0.001
	Positive Rank	14	12.50	300.00		
	Equal	6				
Experimental	Negative Rank	0	.00	.00	1.278*	0.001
	Positive Rank	20	13.25	82.50		
	Equal	4				

**Based on negative ranking*

Table 7 shows that there is a statistically significant difference between the two-tier CT pre-test and post-test scores of control group students (z=1.278, p< .05) in favour of the post-test results. The rank averages also show that there is a statistically significant difference in favour of the post-test results. Table 7 also shows that there is a statistically significant difference between the two-tier CT pre-test and post-test scores of the experimental group students (z=4.287, p< .05) in favour of the post-test results. The rank averages also show that there is a statistically significant difference in favour of the post-test results. The results show that there is not a single student whose pre-test score was higher than his/her post-test score, in the experimental group.

The frequency of the misconceptions which students had was calculated by the two-tier CT pre- and post-tests. In this way, researchers were able to determine, for the experimental group, which misconceptions about 'the umbra, solar and lunar eclipses' had been eliminated and which misconceptions continued. In the control group, the effect of the constructivist approach on eliminating misconceptions was examined. The changes to the understanding that students had developed about 'the umbra, solar and lunar eclipses' between the pre-tests and post-tests are shown in Table 8.

Table 8. Changes in conceptions developed by students about 'umbra, solar and lunar eclipses' from pre-tests to post-tests.

Identified Misconceptions	Control Group (f)			Experimental Group (f)		
	PrT	PoT	CC	PrT	PoT	CC
Light travels as waves.	14	9	+5	13	5	+8
Light cannot pass through glass.	7	4	+3	6	1	+5
The shadow of an object is shorter in the morning than in the noon.	11	12	-1	9	4	+5

Identified Misconceptions	Control Group (f)			Experimental Group (f)		
	PrT	PoT	CC	PrT	PoT	CC
Objects that light can pass through produce a full shadow (umbra).	10	6	+4	12	6	+6
Night-Day occurs when the Moon comes between the Earth and the Sun.	17	10	+7	18	6	+12
Substances that reflect light are called transparent substances.	8	9	-1	8	4	+4
When a shadow occurs, patterns on the objects are also produced in the shadow.	5	3	+2	6	4	+2
During a solar eclipse, the Sun is between the Earth and the Moon.	15	10	+5	13	5	+7
During a lunar eclipse, the Moon is behind the Sun.	14	8	+6	15	7	+8
When an object moves away from a light source, the shape of its shadow changes.	16	6	+10	16	5	+11

PrT: Pre-Test; PoT: Post-Test; f: frequency; CC: Conceptual Change; The (+) sign represents positive conceptual change in students while the (-) sign represents negative conceptual change.

Table 8 shows that before the educational activities, there were several misconceptions of 'the umbra, solar and lunar eclipses' for students in the experimental and control groups alike. When post-test answers for these students were examined, it was observed that the misconceptions of students in both groups had decreased. Table 8 shows a bigger reduction in misconceptions within the experimental group. Thus, positive conceptual change in the experimental group is higher.

Results Obtained From Semi-Structured Interviews

In this research, which aimed to determine the effects of a CBLA on students' understanding of the topics of 'the umbra, solar and lunar eclipses', the results obtained from semi-structured interviews conducted with students in the experimental and control groups after teaching are shown in Table 9.

Table 9. Results obtained from semi-structured interviews.

T	Categories	Quotations	LU	C1	C2	C3	E1	E2	E3	TF
Umbra	Decrease of Shadow	"The shadow is shrinking when we get close to the drape while it is growing when we get close to the flashlight (C1)" "The shadow was shrinking as the Ping-Pong ball moves away from the light source (E2)". "We moved the screen closer and the shadow got bigger (E2)".	CE CE CE	1	1	-	3*	2*	1	8
	Growth of the Shadow	"If I hold the light source closer to the object, the shadow grows (CS4)". "If we hold the light source closer to ourselves, the shadow grows (E2)".	CE CE	1	1	-	1	1	1	5
Solar Eclipse	The Moon is between the Earth and the Sun	"The moon stops at certain point while it is orbiting around the Earth. Then the Sun hits the Moon where it stands and the place where the Moon has stopped becomes dark (C1)".	CE	-	1	-	1	-	-	2
	The Moon is in front of the Sun	"The Moon is in front of the Sun, light is shut off and the Earth gets dark (C1)" "A country is dark during solar eclipse (E3)". "The Moon gets in front of the Sun, its shadow falls on the Earth and the Earth gets dark (E2)".	CE PCE CE	1	-	-	-	1	1	3

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T	Categories	Quotations	LU	C1	C2	C3	E1	E2	E3	TF
Lunar Eclipse	The Sun is between the Earth and the Moon	"Lunar eclipse occurs because the Sun is between the Earth and the Moon (C1)".	EWM	1	-	-	-	-	-	1
	The Earth is between the Sun and the Moon	"The Earth gets between the Sun and the Moon. When the Earth is in front of the Moon, the Moon gets dark (E1)".	CE	-	-	-	1	-	-	1
	The Moon gets behind the Earth	"When the Sun is here, the Moon gets behind the Earth. It waits there for a while and continues to move after a while. For people on this side of the Earth, it becomes night. It gets dark, which is why we don't see it (E2)".	CE	-	-	-	-	1	-	1

** Signs indicate how many times the statement is repeated by the students, not the number of people. T: Themes; LU: Level of Understanding; TF: Total Frequency; CE: Correct Explanation; PCE: Partially Correct Explanation; EWM: Explanation with Misconception*

Data from the semi-structured interviews in Table 9 shows that the students had three major themes about 'the umbra, solar eclipse and lunar eclipse'. Regarding the growth and shrinkage of the full shadow (umbra), it was observed that students C1 and C2 from the control group answered the following questions correctly while student C3 left the answer blank: "Can you explain when the shadow shrinks? Can you demonstrate that with the materials I have given you?" and "We are playing a game with friends. We have a flashlight. Can you tell me how to hold the flashlight so that our shadows are bigger? Can you demonstrate this to me?" Students E1, E2 and E3 from the experimental group all answered the same questions correctly. Regarding a solar eclipse, it was observed that students had two major misconceptions. Students C1 and C2 in the control group answered the following questions correctly while student C3 left the question blank: "Can you explain the reason for the formation of a solar eclipse?" In the experimental group, students E1, E2 and E3 all answered the same question correctly. Regarding a lunar eclipse, it was observed that students had two major misconceptions. One of these misconceptions was that the Sun is between the Earth and the Moon. Student C1 answered the question "Can you explain the reason for the formation of a lunar eclipse?" with "the Sun is between the Earth and the Moon". Students C2 and C3 left the same question blank. In the experimental group, students E1 and E2 answered the question "Can you explain the reason for the formation of a solar eclipse?" correctly while student E3 left the answer blank:

Figures 3and 4 below show the drawings of students in the control and experimental groups in response to interview questions 4 and 6.

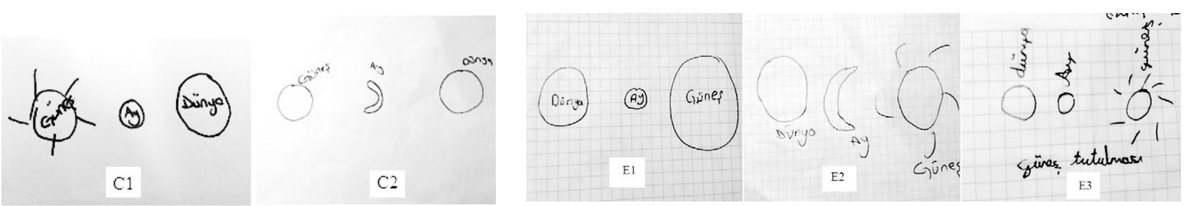

Figure 3: Drawings depicting a solar eclipse of students in the control and the experimental groups.

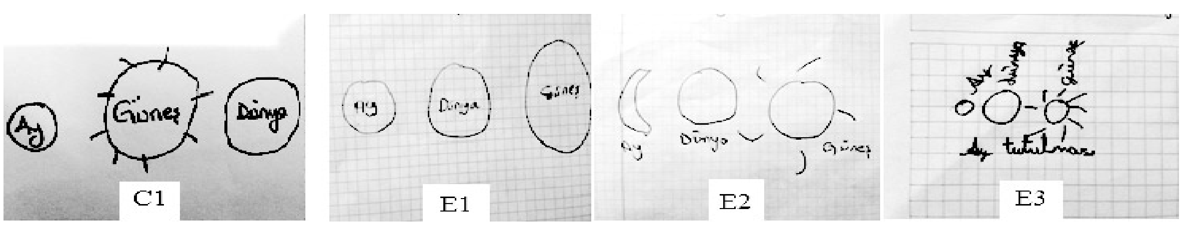

Figure 4: Drawings depicting the lunar eclipse of students in the control and experimental groups.

Discussion

Before the explanation of the topics of 'the umbra, solar eclipse and lunar eclipse', it was observed that there was no statistically significant difference between the experimental and control groups. After teaching, a statistically significant difference was found between the pre-test and post-test scores in favour of the experimental group, where the topics were taught using the CBLA. The study also shows that the post-test scores of students in both groups (experimental and control) increased. The study also shows that, with regard to students' understanding of the topics of 'the umbra, solar eclipse and lunar eclipse', the CBLA that was administered to the experimental group was more effective than the 5E teaching model of constructivist learning approach that was administered to the control group. It can be said that the teaching based on the CBLA was effective in remedying misconceptions and enhancing conceptual understanding of 'the umbra, solar eclipse and lunar eclipse'. The reason of this situation may be the daily life examples and material based on the CBLA used (e.g. Gilbert, et al. 2011; Demircioglu et al., 2013; Broman et al., 2015). In addition, the teaching used a context named 'Buse's Fear' may be facilitate students' learning of the topics of 'the umbra, solar and lunar eclipses'. In fact, a conceptual improvement is always an expected issue after any teaching intervention. For the current teaching intervention, given a 'need to know' and 'Where used in daily life?' basis linking theoretical knowledge with practical one seems to have improved their meaningful learning abilities (Pilot & Bulte, 2006; Demircioglu et al., 2013). These results align with Acar and Yaman's (2011) study, in which students were taught the topic of 'microorganisms' by using different contexts and where students' levels of interest and knowledge also increased. These results are also similar to Karslı and Yiğit (2015), and Ültay's (2015) researches where teaching materials developed using the CBLA were proved to be more effective in transforming trainee teachers' misconceptions into accurate scientific understanding. The results of this study can also be explained with reference to the results of several other studies (e.g. Ulusoy & Onen, 2014; Ültay, 2014), in which the CBLA is proven to improve the retention of information by enabling students to learn concepts in a meaningful way, as well as allowing conceptual development to continue after the initial learning.

Table 8 shows that the presence of misconceptions of students in both groups decreased in the post-test. The decrease in the experimental group was higher than in the control group and this shows that the CBLA leads to more effective meaningful learning than the constructivist learning approach. This situation may be a result of using a worksheet composed from the daily life examples, focused on the students' misconceptions and used CBLA. Since the teaching intervention especially focuses on the students' misconceptions, it is quite reasonable that students will progress in terms of their conceptual understanding of the investigated concepts (Karslı & Çalık, 2012; Karslı & Ayas, 2014). This result is similar to Ültay's (2014) study where it was proved that physics lessons conducted using CBLA were perceived by students as more enjoyable. In addition, Karslı and Yiğit (2015) research shows that lessons conducted using the CBLA are more effective in eliminating misconceptions, erroneous understandings of the topic of "alkanes" than the use of the traditional approach.

The results of the semi-structured interviews show that students in the experimental group answered the interview questions correctly while students in the control group had difficulties answering questions. Some of them were even not able to answer at all. When asked to draw the positions of the Earth, the Sun and the Moon during solar and lunar eclipses, it was observed that all students in the experimental group were able to draw these correctly. However there were some students in the control group who drew the positions incorrectly, and some who were not able to draw them at all. The study also found that there was the misconception that "the Sun coming between the Earth and the Moon causes lunar eclipse" in some of the control group students.

The students in the experimental group have eliminated their misconceptions as either completely or at least greatly, when compared to pre-test. This situation is a direct result of their conceptual understanding having improved through the interventions of researchers using the CBLA. The researchers conclude that teaching materials such as the "Buse's Fear" story and activities conducted in accordance with the CBLA stages had positive effects on students' conceptual understanding. It is a known fact that students are more engaged and able to participate in lessons when the contexts chosen familiar with them and real-life examples suitable for their level are used (Whitelegg & Parry, 1999; King & Ritchie, 2013; Koçak & Önen, 2012; Ulusoy & Onen, 2014). The fact that lessons conducted using the CBLA also enabled students to see scientific concepts as part of their daily lives may also have aided these results. The results may also have been affected by the fact that lessons conducted using the CBLA help students to have more fun and be more active in the classroom (Glynn & Koballa, 2005; Demircioğlu et al., 2009; Gilbert et al., 2011).

Conclusions

The study findings support that the learning environment designed in accordance with the CBLA was a superior instructional tool than the 5E teaching model learning environment in terms of students' conceptual learning performance and eliminating students' misconceptions. The small sample size of the present study reduces statistical power to detect potential effects. This also limits the generalizability of this study. Future studies may be conducted to examine the effects of CBLA on conceptual understanding of larger number students at high school and university level about the astronomy concepts. Teaching materials in accordance with the CBLA did not examine an extraordinary effect in the students' long term memory. Future studies may be conducted to investigate the effects of similar materials on the retention of students' understanding about foundational astronomical phenomena.

The study also found that teaching materials in accordance with the CBLA are more effective in eliminating students' misconceptions (which were identified before the teaching) and help students to achieve accurate conceptual understandings. The present study was not examining the effects of CBLA on all subjects of the astronomy, it examined only 'the umbra, solar eclipse and lunar eclipse' concepts. For other subjects of the astronomy that are abstract and the students find challenging, activities with the CBLA can be developed and their effectiveness can be examined on students' understanding. Moreover, a web source bank of materials easily accessible for astronomy's all topics should be developed and made available for students and school teachers.

In addition, CBLA helped students to link between the scientific concepts and the context related to the daily life. We did not explore the effect of CBLA on students' attitude towards astronomy in the present study. In future studies, it can also be analysed how lessons taught through contexts that are familiar, realistic and closely related to the subject change students' attitude towards astronomy.

Note

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