Indonesian Society for Science Educators
Journal of Science Learning
journal homepage: ejournal.upi.edu/index.php/jslearning

An Examination of the Activities in the Unit "Solar System And Eclipses" in the 6th Grade Science Textbook in Terms of Critical Thinking Standards

Burcu Sarıtaş[1], Merve Lütfiye Şentürk[1], Serkan Aslan[2]*

[1]Department of Science Education, Faculty of Education, Suleyman Demirel University, Isparta, Turkey
[2]Department of Curriculum and Instruction, Faculty of Education, Suleyman Demirel University, Isparta, Turkey
*Corresponding author: serkanaslan@sdu.edu.tr

ABSTRACT The science curriculum aims to provide students with the identity of a researcher, thinking skills, and scientific process skills. Critical thinking skill emerges as one of the skills that should be emphasized in the teaching process in terms of its structural features and the qualities aimed to be given to individuals. For individuals to gain critical thinking skills, they must first gain critical thinking standards. The main purpose of this research is to examine the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook in terms of critical thinking standards. The qualitative research model was used in the research. The data source of the research is the sixth-grade science textbook used in the province of Isparta. The data of the research were collected using the document analysis method. In the analysis of the data, the analysis was made by applying the descriptive analysis method, one of the qualitative data analyses. In line with the analysis, in terms of critical thinking standards, the secondary school sixth-grade science textbook has been determined to meet the standards of clarity, accuracy, significance/relevance, sufficiency, breadth/depth, and precision at a high rate. Based on the research results, suggestions have been developed that textbooks from different disciplines should be examined in line with critical thinking standards and that the activities of different grade-level units in the science curriculum should be examined in terms of critical thinking standards.

Keywords Astronomy, Solar System and Eclipses, Textbook, Critical Thinking Skills, Critical Thinking Standards

1. INTRODUCTION

The rapid change and development in science and technology have affected countries in education and every field. Therefore, developed and developing countries have prioritized training individuals who will keep up with this change and progress and have preferred updating their curricula. In our country, some changes have been made in the science curriculum taught in primary and secondary schools. Among these changes made in the updated science curriculum, it is seen that high-level thinking skills have an important place in the curriculum, and critical thinking skills are tried to be gained in many subjects (MEB, 2018). For this reason, it can be said that the curriculum is organized following the age requirements and in line with the interests and needs of the individuals.

Critical thinking is among the skills that have become a necessity in the process of self-realization of the individual and keeping up with changing technology and innovations (Çakır & Yurtsever, 2013). Paul and Elder (2019) also see critical thinking as the top of thinking. From this point of view, it is stated that critical thinking skill is defined as "a purposeful, self-regulatory judgment that provides interpretation, analysis, evaluation and inference as well as explanation of conceptual, methodological, logical or contextual thoughts" (Facione, 1990) and it has an important place in human life. Critical thinking is a disciplined and self-controlled way of revealing error-free and complete thinking (Sönmez, 2012). It is also closely related to higher-order thinking skills such as decision-making, problem-solving and creative thinking.

For this reason, the basic concepts in critical thinking are research, questioning, interpretation, and judgment (Tuncer, 2017). In this direction, Aslan (2020) defines critical thinking as "a purposeful and systematic thinking that reveals concepts about a subject and the relationship between these concepts, analyzes the events and situations related to the subject, and evaluates this analysis and makes a decision". Critical thinking and other thinking skills appear in every aspect of daily life. Nosich (2012) stated that for individuals to gain critical thinking skills, first of all, critical thinking standards should be gained.

Received: 11 February 2022
Revised: 14 March 2022
Published: 27 July 2022

Critical thinking standards require that thought be within the logic framework and pass specific standards. These standards are classified as clarity, accuracy, significance/relevance, sufficiency, breadth/depth, and precision (Aybek, Çetin, & Başarır, 2014). Clarity standard, whether concepts are clear; accuracy standard, accuracy, and reality of concepts; significance/relevance standard, giving examples of concepts from daily life and whether essential points are emphasized; proficiency standard, whether concepts and ideas are sufficient; breadth/depth standard, sufficiently deep and whether diverse perspectives are in concepts and ideas; the precision standard includes the precision and detail of the concepts and thoughts (Aybek & Aslan, 2016a). It can be said that textbooks are among the essential tools in acquiring critical thinking skills and standards for individuals.

Textbooks have an important place in the effective implementation of all programs developed. For this reason, it is one of the important factors affecting the training program's success. They are materials that guide the teacher and help the students. Students acquire achievements in the science curriculum by using the activities, theoretical knowledge, readings, and studies in the textbooks under the guidance of teachers (Bakır, 2018). From this point of view, textbooks are important in education and training to gain gains in the curriculum. In addition, the activities included in it are a very effective component in gaining the determined gains (Durmaz, 2014). Activities are the whole in-class and out-of-class activities necessary for students to gain gains in the curriculum, acquire skills, and be active under the guidance of teachers (Akyol, 2018). These activities lead to curiosity, research, examination, questioning, observing, and discovering by attracting students' attention. Thus, the development of thinking skills is provided. Thinking skills contribute to students' being active, inquisitive, and investigative and transfer what they have learned to their long-term memory.

Studies that provide students with critical thinking skills and increase their skill levels are included in the textbooks based on achievements. For this reason, the activities in the science textbooks should be created to arouse students' curiosity, motivate them, give them a critical perspective and develop their critical thinking skills. In this direction, science textbooks should encourage students to think scientifically, acquire determined attitudes and behaviors, and think critically (Karakuş, 2009). In order to meet all these requirements, science textbooks should be prepared following critical thinking standards. Therefore, students will be able to gain 21st-century skills.

It is an integrated course that integrates science, astronomy, physics, chemistry, and biology disciplines. In each sub-discipline area, interrelated knowledge and skills are aimed to be developed. The science course is divided into four learning areas determined in this direction: "Earth and Universe, Physical Events, Living Beings and Life, Matter and Nature of Matter". Therefore, it is necessary to develop content and activities suitable for the subjects and concepts in each learning area in order to achieve the teaching objectives. Since science education covers an education process based on natural events, it is impossible to see some events with the naked eye or to encounter them when desired in daily life (Herfana, Nasir, & Prastowo, 2019). For example, observing large space and time scale processes related to earth science from the subject areas of science or performing some chemical reaction experiments is very difficult (Reed et al., 2014).

Similarly, it is often not possible to conduct an experiment on the world and the universe or to directly observe celestial events by students. For this reason, students should learn to question and make inferences based on their critical thinking skills. Considering the opinion of Uçar and Aktamış (2019) that scientific research is carried out by observing systems in the universe, it is thought that developing these skills in the field of astronomy will contribute to the fulfillment of science teaching objectives in a wide range.

As astronomy is one of the oldest sciences (Trumper, 2006), it has an important place in science education (Deniş Çeliker, 2012; Göncü, 2013; Kurnaz & Değirmenci, 2011). However, considering the subjects and concepts in the field of astronomy, it is seen that this field is generally concerned with events that people cannot experience through concrete experiences in their daily lives, and it requires an understanding and mental model building for this. For this reason, it is necessary to carefully prepare the textbooks and the activities in the textbooks on subjects related to the discipline of astronomy and improve the students' thinking skills.

When examining the literature in Turkey, some studies have been found on whether the textbooks meet the critical thinking standards. In the study by Aybek and Aslan (2016a), the document analysis method examined the compliance of two units in the primary school fourth-grade social studies textbook with the standards of critical thinking. Aybek and Aslan (2016b) examined teachers' opinions regarding the compliance of the primary school social studies textbook with the standards of critical thinking. The teachers expressed that the social studies textbook did not follow some standards. In the study conducted by Aybek et al. (2014), the compliance of the activities in science and technology textbooks with the critical thinking skill standards was examined. According to the research results, the activities in the textbook did not meet some standards. Few studies examining the compliance of the activities in the secondary school science textbook with the standards of critical thinking have been evaluated as a shortcoming by the researchers.

For this reason, it is thought that this research will fill this gap in the literature. As it is known, science is one of the disciplines that contribute most to developing critical

thinking skills due to its nature suitable for questioning, researching, and structuring knowledge. However, children mostly learn about astronomical events, which have an important place in science, informally due to their indirect experiences in their daily lives (Hannust & Kikas, 2007). This may cause them to mislead their questioning skills. For this reason, it is necessary to prepare the activities to be done in the classroom to improve the quality and thinking skills. In this direction, it is thought that it is crucial to determine the critical thinking standards of science activities prepared based on the achievements in the science curriculum. Therefore, the results of this research will guide the publishing houses in preparing the science textbook published in different countries.

Furthermore, it is thought that these research results will guide publishers in organizing activities for critical thinking standards while preparing science textbooks. In this direction, the research aims to examine the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook, following the critical thinking standards set forth by Nosich (2012). Based on this aim, answers to the following questions were sought within the scope of the research. Activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook:

1. Does it meet the clarity standard?
2. Does it meet the accuracy standard?
3. Does it meet the significance/relevance standard?
4. Does it meet the sufficiency standard?
5. Does the breadth/depth meet the standard?
6. Does it meet the precision standard?

2. METHOD

2.1 Research Design

The qualitative research model was used in this research conducted to determine whether the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the standards of critical thinking. Qualitative research is defined by Yıldırım and Şimşek (2011) as "research in which qualitative data collection methods such as observation, interview, and document analysis are used, and a qualitative process is followed to reveal perceptions and events in a natural environment realistically and holistically". In the study, data were collected according to the document analysis method, one of the qualitative data collection methods. Document analysis includes the analysis of written materials containing information about the case or cases that are aimed to be investigated (Yıldırım & Şimşek, 2011). In other words, it is the process of collecting the records and documents related to a study and coding them according to a particular system (Karasar, 2012). In this research, the document review method was used since the activities in the science textbook prepared according to the sixth-grade science curriculum were examined in terms of critical thinking standards.

2.2 Data Source

As the data source of the research, the sixth-grade science textbook taught in the province of Isparta by the Ministry of National Education in the 2018-2019 academic year was used. This book was chosen because it was accepted by the Board of Education and Discipline and used throughout the country in the 2018-2019 academic year. Within the scope of the research, it was examined whether the activities in the unit named "Solar System and Eclipses" in the sixth-grade science textbook meet the standards of critical thinking. The main reason for choosing this unit is that the achievements in the unit include critical thinking.

2.3 Analysis of Data

Yıldırım and Şimşek (2011) stated that document review consists of five stages. These;

1. Accessing the Document: At this stage, the researcher must determine the document based on the purpose of the research and reach the relevant document. In this context, the researchers reached the sixth-grade science textbook.
2. Checking Authenticity: At this stage, it is necessary to check whether the document reached by the researchers is original or not. If the relevant document's originality is not checked, if the document is examined within the scope of the research, the reliability of the research will be damaged. For example, within the scope of this research, the original sixth-grade science textbook was reached. For this, a sixth-grade science textbook was taken from a secondary school in Isparta and examined within the research scope. In this way, it was tried to increase the reliability of the research.
3. Understanding Documentation: The document must be understood and analyzed correctly at this stage. The document reached within the scope of the research should be examined systematically. In this research, the activities related to Solar System and Eclipses unit in the sixth-grade science textbook were handled and examined within the framework of the critical thinking standards of the research conducted by Aybek and Aslan (2016a).
4. Analysis of Data: In the analysis of the data, descriptive analysis was used as it was desired to explain the existing situation by examining the suitability of the "Solar System and Eclipses" unit in the sixth-grade science textbook in line with the critical thinking standards. According to Yıldırım and Şimşek (2011), descriptive analysis "is done to present the findings to the reader in an organized and interpreted way." The findings obtained in the descriptive analysis are analyzed and presented within the framework of predetermined themes. This study's findings were organized and interpreted according to the themes within the framework of predetermined critical thinking standards. In the research, the activities in the examined textbook were examined one by one to whether they were in line with the standards of critical thinking. The results are shown in the tables. In the tables, the (+) sign indicates that there is a critical thinking standard; the (-) sign does

Table 1 Findings on the clarity standard

Clarity Standard	1. Unit: Solar System and Eclipses	
	Activity 1: Let's Make a Model of the Solar System	Activity 2. How are the Sun and Moon Eclipsed?
It is written clearly.	+	+
It is easily understood	+	+
Concepts explained	+	+
It is plain	+	+
Explained in detail	+	+
Made concrete with examples	+	+
Supported by images	+	+
Explained in a language suitable for the target audience	+	+

not. In the research, analysis was made by considering the standard expressions of critical thinking determined by Aybek and Aslan (2016a).

5. Reporting Data: At this stage, the findings obtained by the researchers should be reported. In this study, the findings were reported.

2.4 Validity and Reliability

The quality of the research done generally depends on the reliability and validity of the study. In qualitative research, validity means observing the researched subject as it is and impartially (Yıldırım & Şimşek, 2011). Reporting the data collected in the research and explaining how the results were reached in detail are essential criteria of validity in qualitative research. In order to ensure the validity of this research, the data analysis is explained in detail in the findings section, using direct quotations from the visuals and in-text expressions. In research, reliability refers to how repeatable the findings are. In order to ensure reliability in this research, the data analysis was also carried out by a field expert who wrote a doctoral thesis in the field of critical thinking skills, independent of the researcher. The reliability formula [Reliability = Agreement / (Agreement + Disagreement)] proposed by Miles and Huberman (1994) was used to determine the coefficients of agreement between the independent codings of both researchers. As a result, the harmony between the expert and the researcher was determined as 98% in clarity standard, 97% in accuracy standard, 93% in significance/relevance standard, 86% in proficiency standard, 87% in breadth/depth standard, and 89% in precision standard. The general compliance with the standards was determined as 90%. The analysis was sufficient and reliable since the reliability calculations were considered reliable for the research (Miles & Huberman, 1994) when the reliability calculations were over 70%. Making direct citations in qualitative research is a strategy that increases the validity and Reliability (Güçlü, 2021; Karagöz, 2021). In this study, the validity and reliability of the research were increased by including the visuals in the textbook.

3. FINDINGS

The findings of the studies were analyzed around the standards of clarity, accuracy, significance/relevance, breadth/depth, and precision and presented in tables.

3.1 Clarity Standard

For the clarity standard, the concepts should be understood clearly and in detail, the concepts and examples should be made concrete and supported with visuals, and they should be simple and understandable. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the clarity standard are presented in Table 1.

The "Solar System and Eclipses" unit in the sixth-grade science textbook is included in the "Earth and Universe" learning area in the curriculum (Figure 1). There are two activities in the unit: "Let's Make a Solar System Model" and "How the Sun and Moon are Held". "Let's Make a Solar System Model" is the first event of the unit. The following findings were obtained when the efficacy was analyzed according to the clarity standard. It has been determined that the activity examined based on the clarity standard was prepared following the unit's achievements and provided each sub-dimension of this standard.

For example, "F.6.1.1.2. It creates a pattern by ranking the planets in the solar system according to their proximity to the Sun." The activity covering the learning outcome is clearly expressed and allows students to understand the subject. "Many celestial bodies are revolving around the Sun. The distances of these celestial bodies to the Sun, their structures, and the paths they follow are different from each other. This system, which consists of the Sun, planets, satellites of planets, asteroids, and comets, is called the Solar system" expressions support this finding. When examining the activities in the Solar System and Eclipses unit, it was seen that this unit's fundamental concepts are explained in the activities in the textbook. For example, "Compares the planets in the solar system with each other." In line with the learning outcome, it is seen that the textbook includes information about the planets in the solar system.

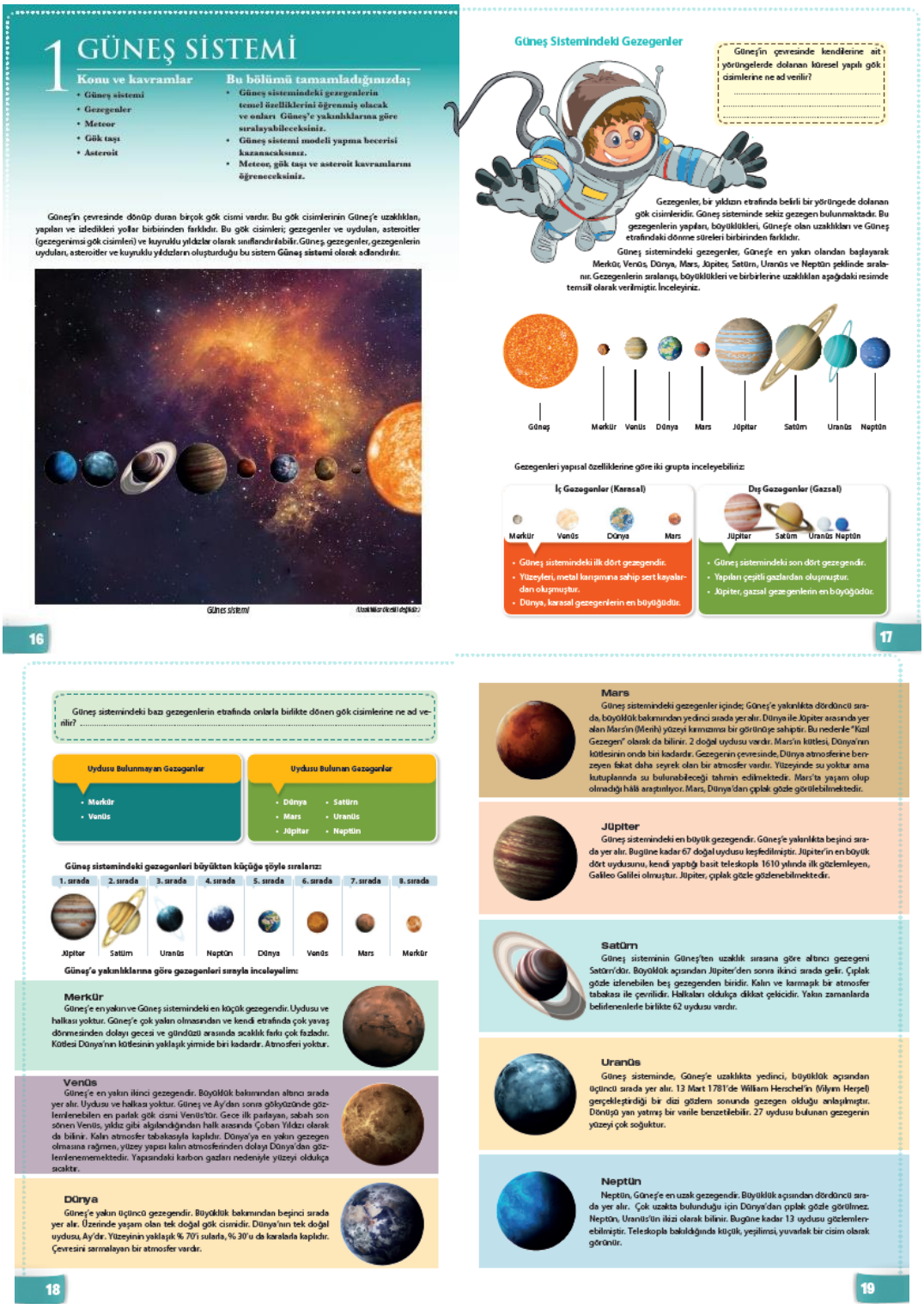

Figure 1 The "Solar System and Eclipses" unit in the sixth-grade science textbook

In the activities in the Solar System and Eclipses unit, the subject integrity is written simply. Unnecessary details and piles of information are not included. Within the scope of the sixth-grade science curriculum achievements, each concept and activity examined was explained to the student in detail. The information in the sixth-grade science textbook has been made concrete with examples. For example, giving information about the world's most giant meteorite pit in California in the textbook and asking students to build a solar system model are activities that allow students to embody the subject (Figure 2). It is seen that the activities in the Solar System and Eclipses unit textbook are supported by visuals suitable for the content of the unit (Figure 3).

Figure 2 Information examples in the sixth-grade science textbook

Figure 3 Visuals for the content of the unit

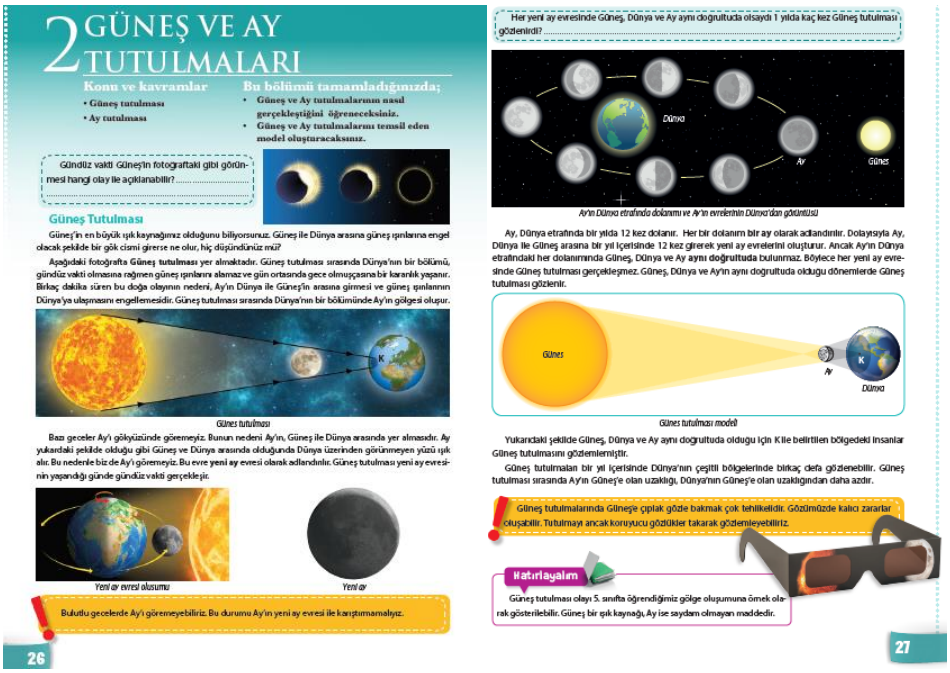

Figure 4 The Solar System and Eclipse unit

It can be said that the activities in the Solar System and Eclipses unit (Figure 4) were transferred to the achievements of the sixth-grade students in an appropriate language. In conclusion, since the "Let's Make a Solar System Model" activity meets most of the clarity standard criteria, it can be said that this activity highly meets the clarity standard, one of the critical thinking standards.

The second activity of the Solar System and Eclipses unit is the "How is the Sun and Moon Held?" activity. The following results were obtained when the effectiveness was analyzed according to the clarity standard. It has been determined that the subjects in the activity and the unit match the acquisition of the objective and are written clearly according to the achievement of the given activity. For example, "F.6.1.2.3. It creates a model that represents a solar and lunar eclipse." The subject and the activity content are included in the book by associating them according to the learning outcome. When the content of

the activity and the subject is examined, it is seen that it has a simple and understandable structure when the narration is examined in terms of sentence structure. For example, in the activity in the textbook, during a solar eclipse, a part of the Earth cannot receive the Sun's rays even though it is daytime, and darkness is experienced in the middle of the day as if it were night. During a solar eclipse, the Moon's shadow forms on the Earth's part. It can be said that the expressions are suitable for the level of the students, simple and understandable. The concepts in the Solar System and Eclipse unit are explained in the book within the scope of the activity and subject content. For example, "Predicts how the solar eclipse occurred." In line with the acquisition, information about the solar eclipse is given.

The subject's integrity was written simply in the activity. Unnecessary details and piles of information are not included. Within the scope of the sixth-grade science curriculum achievements, each concept and activity examined was explained to the student in detail. The information about the event has been made concrete with examples. For example, giving the visual of protective glasses in the event and information about eye protection during solar eclipses can be expressed as the concretization of the event (Figure 5). Therefore, it can be said that visuals supported the subject content and activities in the event.

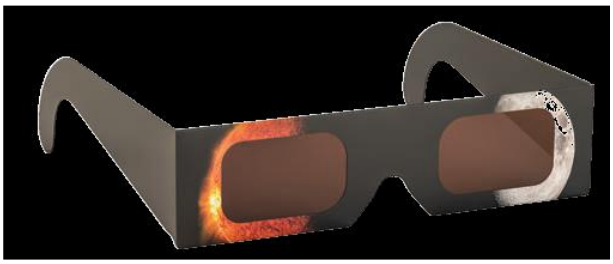

Figure 5 The visual of protective glasses

Figure 6 are the images of the solar and lunar eclipses in the textbook.

In the activity, the subject and activities scopes are conveyed to the sixth-grade students in a language appropriate to the new curriculum and achievements. In conclusion, since the activity meets most of the criteria of the clarity standard, it can be said that it meets the clarity standard, one of the critical thinking standards, at a high rate.

3.2 Accuracy Standard

For the accuracy standard, the concepts must be correct and proceed in the correct order, and the concepts must be reliable and accurate. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the accuracy standard are presented in Table 2.

The following results were obtained in the analysis of the "Let's Make a Solar System Model" activity in the textbook on Solar System and Eclipses according to the accuracy standard. When the information given in the topics and activities is examined in line with the curriculum and achievements, its accuracy has been determined. In line with the unit gains, the information in the book is given in the correct order according to the acquisition order. For example, "F.6.1.1.1. It compares the planets in the solar system with each other." Firstly, information about the "Solar System" was included in the activity aimed at learning. When the activities in the textbook were examined, it was seen that appropriate examples were given. For example, it can be said that the world's giant meteorite pit in California is a suitable example. In the Let's Model of the Solar System activity, the cause and effect relationship is tried to be revealed. For example, "Mercury is the closest planet to the Sun and the smallest planet in the solar system. Since it is very close to the Sun and rotates

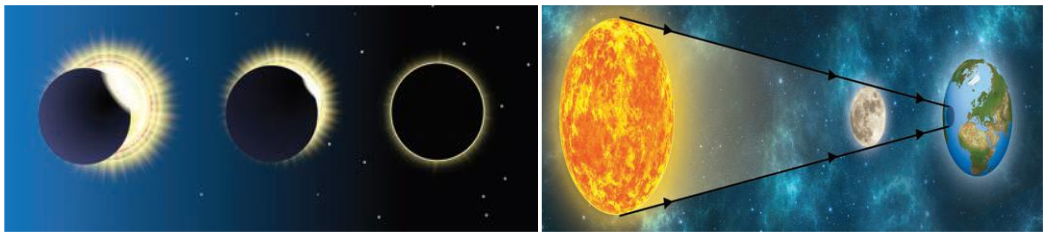

Figure 6 The images of the solar and lunar eclipses in the textbook

Table 2. Findings regarding the accuracy standard

Accuracy Standard	1. Unit: Solar System and Eclipses	
	Activity 1: Let's Make a Model of the Solar System	Activity 2. How are the Sun and Moon Eclipsed?
The information given is correct.	+	+
The information is given in the correct order.	+	+
Examples suitable for the subject are given.	+	+
There is a cause-and-effect relationship.	+	+
The information given is based on reliable sources.	-	-

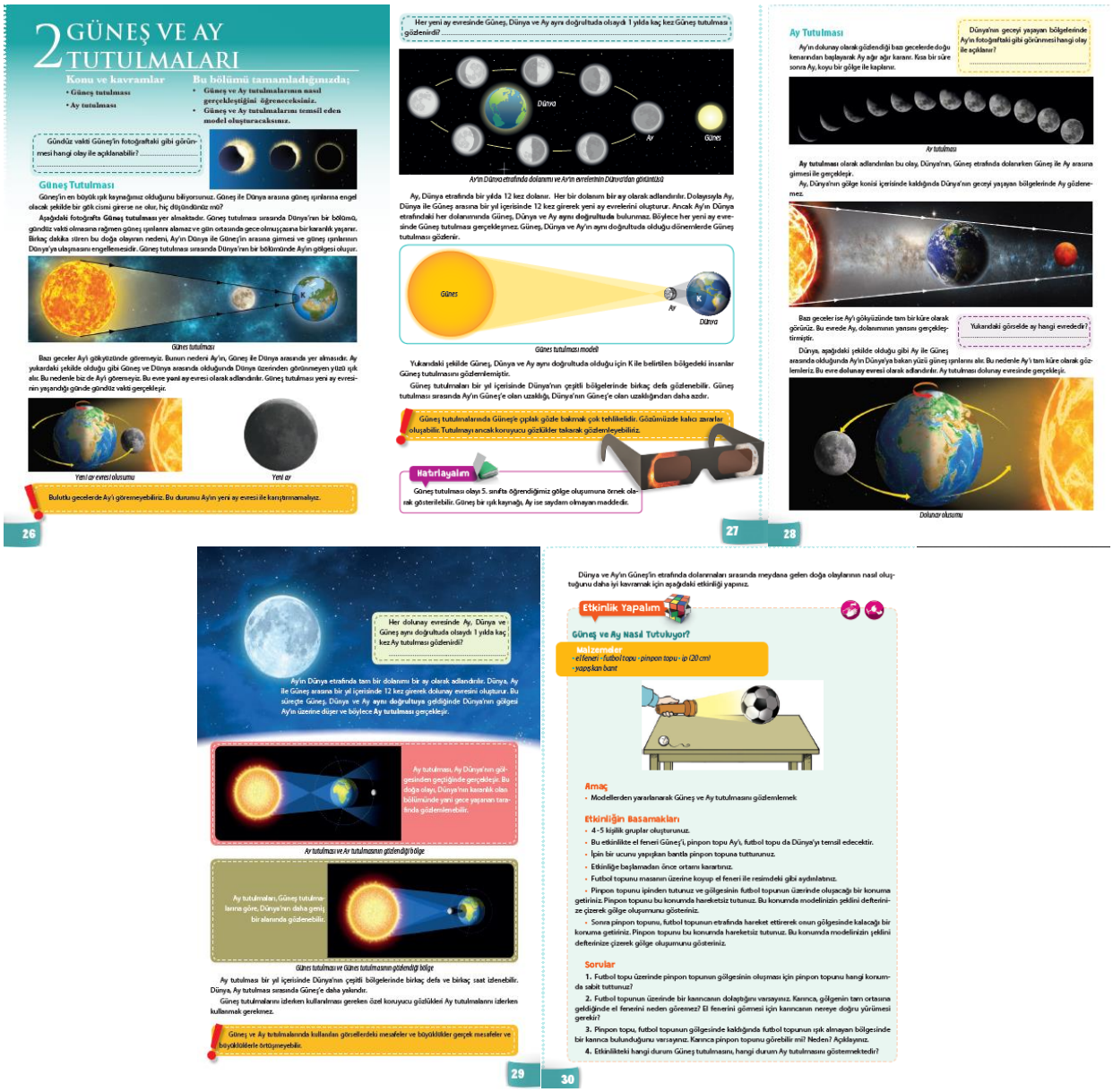

Figure 7 The information given within the scope of the activity is given in order

very slowly around itself, the temperature difference between night and day is huge. Therefore, an attempt was made to establish a cause-effect relationship in the statement. The sources of the information given in the textbook are not shown within the scope of the "Let's make a solar system" model activity. As a result, it can be said that the "Let's Make a Solar System Model" activity meets most of the standard accuracy criteria, so it can be said that this activity meets the accuracy standard, which is one of the critical thinking standards, at a high rate.

The following results were obtained in analyzing its effectiveness according to the accuracy standard. When the information given in the topics and activities in the book is examined in line with the curriculum and achievements, its accuracy has been determined. In line with the unit achievements, it was seen that the information in the activity in the book was correct according to the acquisition order. For example, "F.6.1.2.1.predicts how the solar eclipse occurs. F.6.1.2.2. It predicts how the lunar eclipse occurred." It has been determined that the information given within the scope of the learning outcomes is given in the correct order. When the visuals of the activity in the book are examined (Figure 7), it is seen that the information given within the scope of the activity is given in order.

It can be said that the examples in the activity are suitable for the subject. Explaining the Solar and Lunar eclipses with illustrated visuals and the examples in the event being relevant to the subject can be given as examples. It can be said that there is a cause-effect relationship in the activity. For example, "During a solar eclipse, a part of the Earth cannot receive the Sun's rays even though it is daytime, and there is darkness as if it were a night in the middle of the day. This natural phenomenon

lasts for a few minutes when the Moon enters between the Earth and the Sun and prevents the Sun's rays from reaching the Earth. During a solar eclipse, the Moon's shadow forms on the part of the Earth, indicating the establishment of a cause-effect relationship. The textbook's information source within the scope of How the Sun and the Moon are kept is not shown. As a result, since the activity meets most of the criteria of the accuracy standard, it can be said that it meets the accuracy standard, one of the critical thinking standards, at a high rate.

3.3 Importance/Relevance Standard

While transferring the concepts for the significance/relevance standard, it is necessary to include daily life examples, emphasize important places, and establish a link between the concepts. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the significance/relevance standard are presented in Table 3.

The following results were obtained when the "Let's Make a Solar System Model" activity in the Solar System and Eclipses unit was analyzed according to the significance/relevance standard. First, it can be said that the information in this activity has an important place in the students' daily life. Giving information about the place of the Earth in the solar system and the effects of the events in this system on people includes important information that students can use in their daily lives. Second, the topics of the event are divided into main and subtopics. For example, sub-topics of the first main subject, "Solar System," were created, and the Solar system was explained. Important points were emphasized on the topics included in the event. For example, information about concepts such as the Solar System, Planets, Meteors, Meteorites, and Asteroids are given in the boxes, and their important places are emphasized. Third, it can be said that the subjects of the activity are interrelated with each other. As the first topic, it is seen that the Solar System, Planets, Meteors-Asteroids, and Asteroids are mentioned, and there is a connection between the topics. The basic and powerful concepts that should be given in the subject of the activity are emphasized. For example, planets in the Solar system and their properties are mentioned. As a result, since the "Let's Make a Solar System Model" activity meets most of the significance/relevance standard criteria, it can be said that this activity meets the significance/relevance standard of the critical thinking standards at a high level.

The following results were obtained when their effectiveness was analyzed according to the significance/relevance standard. It can be said that the information in the activity has an important place in the students' daily life. "F.6.1.2.1.Predicts how the solar eclipse will occur.", "F.6.1.2.2. It predicts how the lunar eclipse occurred." The achievements emphasize how the Solar and Lunar eclipses we encounter in daily life occur. Topics of the event are divided into main and subtopics. For example, the title of "Solar and Lunar Eclipses" is explained by separating the titles of Solar Eclipse and Lunar Eclipse.

Important p oints were emphasized on the topics included in the event. For example, information about Solar and Lunar eclipses is explained in different colors and boxes. It can be said that the subjects of the activity are interrelated with each other. As the first topic, Solar Eclipse and Lunar Eclipse are mentioned, and it is seen that there is a connection between the subjects. The basic and powerful concepts that should be given in the subject of the activity are emphasized. For example, the solar and lunar eclipses concepts are explained in color. As a result, since the activity meets most of the criteria of the significance/relevance standard, it can be said that this activity meets the significance/relevance standard of the critical thinking standards at a high rate.

3.4 Sufficiency Standard

Concepts, activities, evidence, and time must be sufficient for the proficiency standard. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the clarity standard are presented in Table 4.

When the "Let's Make a Solar System Model" activity in the Solar System and Eclipses unit was analyzed according to the sufficiency standard, the following results were obtained. It is seen that the information in the subjects in the unit is sufficient in line with the gains that should be gained in the sixth-grade science curriculum. For example, "The basic properties of the planets (terrestrial, gaseous, inner planet, outer planet) are mentioned." according to his gain, It can be said that the information

Table 3 Findings on the significance/relevance standard

Importance/Relevance Standard	1. Unit: Solar System and Eclipses	
	Activity 1: Let's Make a Model of the Solar System	Activity 2. How are the Sun and Moon Eclipsed?
It has importance in the daily life of students.	+	+
Main and sub-points are separated from each other	+	+
Key points highlighted	+	+
There is a connection between the topics.	+	+
Core and powerful concepts are evident	+	+

Figure 8 The information in the Solar System and Eclipses unit

Table 4 Findings on the sufficiency standard

Sufficiency standard	**1. Unit: Solar System and Eclipses**	
	Activity 1: Let's Make a Model of the Solar System	Activity 2. How are the Sun and Moon Eclipsed?
The relevant information is sufficient.	+	+
It included enough activities	+	+
Sufficient evidence has been presented	+	+
The subject has been viewed from many angles.	+	-
It showed sufficiency in terms of time.	+	+

given about the planets is sufficient. In Figure 8, it is seen that the information is sufficient.

In line with the achievements in the sixth-grade science curriculum, it can be said that the activities in the unit are generally sufficient. The activities in the unit contain sufficient evidence in line with the achievements given in the curriculum. In the event, "Which materials did you use to create your model?" "How would you order the celestial bodies in the solar system from largest to smallest?", "How would you order the distances of the planets from the Sun from near to far?" It can be said that students can look at the subject from many different perspectives. It can be said that the time allocated to the activities is sufficient. It can be said that the proficiency standard, one of the critical thinking standards, is met at a high rate.

The following results were obtained when their effectiveness was analyzed according to the proficiency standard. It is seen that the information contained in the unit subjects is sufficient in line with the gains that should be gained in the program. For example, "Predicts how the lunar eclipse occurred." according to his gain, It can be said that the information given about the lunar eclipse is sufficient. In Figure 9, it is seen that sufficient information is given about the solar and lunar eclipses.

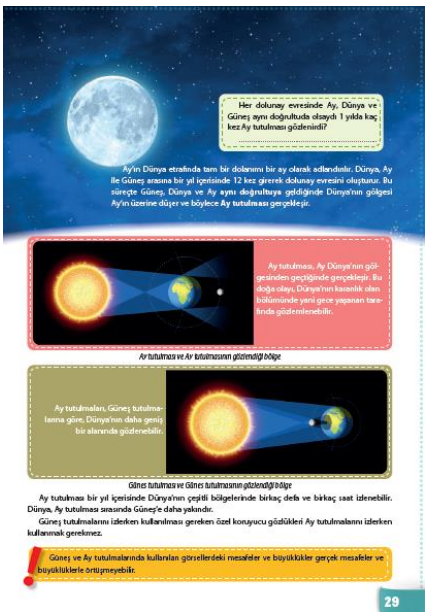

Figure 9 Information about the solar and lunar eclipses

Table 5 Findings on the breadth/depth standard

Breadth/Depth Standard	1. Unit: Solar System and Eclipses	
	Activity 1: Let's Make a Model of the Solar System	Activity 3. How are the Sun and Moon Eclipsed?
Topics are explained down to the smallest detail.	+	+
In-depth information on the subjects is given.	+	+
Topics are covered extensively.	+	+
Different perspectives are included.	+	-

Table 6 Findings on the precision standard

Precision Standard	1. Unit: Solar System and Eclipses	
	Activity 1: Let's Make a Model of the Solar System	Activity 2. How are the Sun and Moon Eclipsed?
It is faultless.	+	+
It is detailed enough.	+	+
Activities are related to achievements.	+	+
The reasons for the events are explained.	+	+
The results contain precision.	+	+

In line with the achievements in the sixth-grade science curriculum, it can be said that the activities in the unit are generally sufficient. The activities in the unit contain sufficient evidence in line with the achievements given in the curriculum. For example, in the activity, "In which position did you hold the ping-pong ball fixed so that the shadow of the ping-pong ball would form on the soccer ball? ?" In line with the statements, it can be said that the students can look at the subject from many different perspectives. It can be said that the time allocated to the activities is sufficient. As a result, "How is the Sun and Moon Held?" Since the activity meets most of the criteria of the proficiency standard, it can be said that it meets the proficiency standard, one of the critical thinking standards, at a high rate.

3.5 Breadth/Depth Standard

For the breadth/depth standard, the concepts should be explained to the smallest detail, discussed in detail, and different perspectives should be included. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the breadth/depth standard or not are presented in Table 5.

The following results were obtained when the "Let's Make a Solar System Model" activity in the Solar System and Eclipses unit was analyzed according to the breadth/depth standard. The subjects in the activity were explained in detail in line with the curriculum and achievements. For example, the subjects of the Solar System, Solar, and Lunar eclipses include the determined achievements and give place to details. The topics included in the event include in-depth information in line with the program and achievements. For example, there is in-depth information on planets and their properties. The subjects were discussed broadly in line with the scientific information, visuals, and embodied expressions. For example, the meteorite that fell on California was mentioned in detail, and the image related to this event was used. In the event, "What materials did you use to create your model?" "How do you order the celestial bodies in the solar system from largest to smallest?", "Do the planets move around the Sun only in their orbits? Why is this important?" The questions enable students to look at the subject from different perspectives. As a result, it can be said that this activity meets the breadth/depth standard, which is one of the critical thinking standards, since the activity "Let's Make a Solar System Model" meets most of the breadth/depth standard criteria.

The following results were obtained when its effectiveness was analyzed according to the breadth/depth standard. First, the subjects in the activity were explained in detail in line with the curriculum and achievements. It contains in-depth information aligned with the topics, program, and achievements. For example, there is in-depth information on Solar and Lunar eclipses. The subjects were discussed broadly in line with the scientific information, visuals, and embodied expressions. For example, the subject content and the images about the Solar and Lunar eclipses show that the subject has been conveyed widely.

"Assume an ant is walking on a soccer ball. Why can't the ant see the flashlight right in the middle of the shadow? Where does the ant have to walk in order to see the flashlight?", "Assume that an ant is in the shaded area of the soccer ball when the ping-pong ball is in the shadow of the soccer ball. Can the ant see the ping pong ball? Why? Please explain." It is seen that the questions are questions that require students to look at the event from different perspectives. As a result, since the activity meets most of the criteria of the breadth/depth standard, it can be said that it highly meets the breadth/depth standard, one of the critical thinking standards.

3.6 Precision Standard

For the precision standard, the concepts must be error-free, precise, and detailed, and the reasons for the events must be explained. The findings regarding whether the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook meet the precision standard are presented in Table 6.

The following results were obtained when the "Let's Make a Solar System Model" activity in the unit named solar system and eclipses were analyzed according to the precision standard. It can be said that the subjects in the "Let's make a solar system" model activity are error-free. It can be stated that the information in the activity is suitable for the achievements in the sixth-grade science curriculum, and the information is consistently included in the activity. The subjects in the activity are given in sufficient detail based on the achievements in the curriculum. For example, "F.6.1.1.1. It compares the planets in the solar system with each other." In line with the acquisition, detailed information about the planets in the solar system has been given. "Let's make a solar" system model activity can be related to the curriculum's achievements. For example, the activity "builds a model by sorting the planets in the solar system according to their proximity to the Sun." appears to be geared towards gain. The reasons for the events taking place in the event are explained. For example, "There are also celestial bodies called meteorites in space. Solid objects in space, whose dimensions are incomparably smaller than stars and planets, are called meteors when they enter the Earth's atmosphere. The meteors entering the atmosphere at high speed start to burn due to the high heat that arises due to their friction with the materials that make up the atmosphere, and they become incandescent and scatter light around them. Although this natural phenomenon has nothing to do with the stars, it is popularly known as a falling star or shooting star. The meteor then turns into a gas due to the high temperature in the atmosphere and becomes invisible, or the remaining part of the meteor, due to combustion, falls to the Earth. The reasons for the events are explained in the text. The Let's Model the Solar System activity results contain precise information. For example, "The planets in the solar system are listed as Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, starting from the closest to the Sun.", "Earth's only natural satellite is the Moon." As a result, since the "Let's Make a Solar System Model" activity meets most of the standard precision criteria, it can be said that this activity meets the precision standard, one of the critical thinking standards, to a high degree.

The following results were obtained when their effectiveness was analyzed according to the precision standard. It can be said that the information about the subjects in the event is free of errors. It can be said that the subjects in the activity are given in sufficient detail in line with the curriculum and achievements. For example, "F.6.1.2.1.Predicts how the solar eclipse will occur.", "F.6.1.2.2. It predicts how the lunar eclipse occurred." It is seen that detailed information was given in the event in line with the achievements. The topics in the activity are related to the achievements.

For example, "Creates a model that represents a solar and lunar eclipse." achievement "How is the Sun and Moon Held?" match its effectiveness. The reasons for the events taking place in the event are explained. For example, "During a solar eclipse, a part of the Earth cannot receive the Sun's rays even though it is daytime, and there is darkness as if it were a night in the middle of the day. This natural phenomenon lasts for a few minutes when the Moon enters between the Earth and the Sun and prevents the Sun's rays from reaching the Earth. Therefore, during a solar eclipse, the shadow of the Moon forms on the part of the Earth. The reason for the event is explained in the text. The information contained in the event contains scientific certainty. For example, "The Moon goes around the Earth 12 times a year. Each cycle is called a month. Therefore, the Moon enters between the Earth and the Sun 12 times a year, and forming new moon phases is a scientific knowledge with generally accepted certainty. As a result, since the activity meets most of the criteria of the precision standard, it can be said that it meets the precision standard, one of the critical thinking standards, at a high rate.

4. DISCUSSION

The main purpose of the research is to examine the activities in the "Solar System and Eclipses" unit in the middle school sixth-grade science textbook in line with the critical thinking standards set forth by Nosich (2012). Within the scope of the research, whether the activities in the "Solar System and Eclipses" unit in the science textbook taught in the sixth grade of secondary school in Isparta province meet the standards of critical thinking were systematically examined. As a result of the research, it was concluded that the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook met the critical thinking standards of clarity, accuracy, significance/relevance, sufficiency, breadth/depth, and precision at a high level. This is a significant result of our research because this result indicates that the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook are organized by considering critical thinking. In astronomy, critical thinking is generally seen as a skill to be developed (Heafner, 2015). The first source that will organize the student, teacher, and content in line with this goal is undoubtedly the textbooks. It has become a necessity now to give importance to critical thinking in the textbooks and to prepare the content of the textbooks in a way that will develop critical thinking (Öztürk & Razgatlıoğlu, 2013). The positive results of the studies in the literature that are taught based on activities and

methods that will develop critical thinking in the field of astronomy (For example; Allen & Kelly-Riley, 2005; Costa & Johnson, 2020; Demirci & Özyürek, 2017; Ridlo, Dafik, & Nugroho, 2020; Taufiq, Wijayanti, & Yanitama, 2020).

Today, it is known that the most used teaching material in the teaching-learning process by teachers is textbooks. In this respect, it is crucial to organize textbooks by considering high-level thinking skills. Based on our research results, the sixth-grade science textbook was designed considering the standards of critical thinking also shows that students are trying to gain 21st-century skills. In this case, it is promising for the future. Today developed countries consider 21st-century skills while arranging their curricula. When the updated science curriculum in Turkey is examined, it is seen that it has been organized considering 21st-century skills (MEB, 2018). In this respect, it can be said that publishing houses organize the activities in the textbooks, taking into account the curricula. When the literature is examined, it has been found that studies have different results from the result of this research. In the study conducted by Aybek and Aslan (2016a), it was determined that the activities in the "I'm Learning My Past" and "Where We Live" units in the social studies textbook do not meet the critical thinking standards sufficiently.

Similarly, in another study by Aybek and Aslan (2016b) about teachers' opinions on whether the social studies textbook meets the standards of critical thinking or not, it was stated by the teachers that the social studies textbook did not sufficiently meet the critical thinking standards. Likewise, as a result of the research conducted by Aybek et al. (2014), it was concluded that the activities in the science and technology textbook do not meet the critical thinking standards sufficiently. Examining different textbooks at different times can be shown as the reason why these studies differ from our research results. In addition, examining different units may cause this difference to emerge. The fact that higher-order thinking skills were emphasized more in the updated curricula and that publishers took into account the studies aimed at developing thinking skills may also have caused the high level of critical thinking standards to be met in our study.

CONCLUSION

As a result of the research, it was concluded that the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook met the critical thinking standards of clarity, accuracy, significance/relevance, sufficiency, breadth/depth, and precision at a high level. This result reveals that the 6th-grade science textbook was prepared to develop critical thinking skills, one of the 21st-century skills. Based on this result, it can be stated that the 6th-grade science textbook has been designed by considering critical thinking skills and standards. As a result, it is a significant result of the research that the activities in the "Solar System and Eclipses" unit in the sixth-grade science textbook met the standards of critical thinking at a high level. In this way, it can be stated that the development of student's critical thinking skills will be easier.

SUGGESTION

Based on the results achieved in the research, the following suggestions can be made to researchers, science teachers, and academics working in this field:

1. This research is limited to the activities of the "Solar System and Eclipses" unit in the sixth-grade science textbook. In line with critical thinking standards, researching whether the units in all science textbooks from primary school third grade to secondary school eighth grade meet the critical thinking standards will contribute to the literature.
2. Including similar studies in other disciplines and at different grade levels is recommended.

ACKNOWLEDGMENTS

This research was produced from the master's thesis conducted by the first author under the supervision of the second and third authors.

REFERENCES

Akyol, P. (2018). *İlkokul üçüncü sınıf hayat bilgisi dersi kılavuz kitabındaki okul heyecanım temasında yer alan etkinliklerin ara disiplin kazanımları açısından öğretmen görüşlerine göre değerlendirilmesi* [Evaluation of the activities included in the theme of school excitement in the primary school third grade life studies course guide book in terms of intermediate discipline achievements according to the opinions of the teachers]. (Unpublished master's thesis). Çukurova Üniversitesi, Adana.

Allen, M. L., & Kelly-Riley, D. (2005). Promoting undergraduate critical thinking in Astro 101 lab exercises. *Astronomy Education Review*, *4*(2), 10-19.

Aslan, S. (2020). The relationship between secondary school students' critical thinking levels and their attitudes towards reading. *International Online Journal of Educational Sciences*, *12*(5), 114-123.

Aybek, B., & Aslan, S. (2016a). An analysis of the units "I'm learning my past" and "the place where we live" in the social studies textbook related to critical thinking standards. *Eurasian Journal of Educational Research*, *65*, 35-54.

Aybek, B., & Aslan, S. (2016b). An examination of teachers' views regarding the conformity of social studies textbooks to the critical thinking standards. *Journal of Education and Training Studies*, *4*(11), 12-20.

Aybek, B., Çetin, A., & Başarır, F. (2014). Fen ve teknoloji ders kitabının eleştirel düşünme standartları doğrultusunda analiz edilmesi [Analyzing the science and technology textbook in line with critical thinking standards]. *Eğitim ve Öğretim Araştırmaları Dergisi*, *3*(1), 313.

Bakır, E. (2018). *Fen bilimleri ders kitapları Unit sonu değerlendirme çalışmalarının yapısal ve bilişsel özellikleri açısından incelenmesi* [Examination of end-of-unit evaluation studies in science textbooks in terms of structural and cognitive features]. (Unpublished master's thesis). Kastamonu Üniversitesi, Kastamonu.

Çakır, G., & Yurtsever, B. (2013). An Assessment of Critical Thinking Skills based Architectural Project Course in Terms of Student's Outputs. *Procedia-Social and Behavioral Sciences*, *106*, 348-355.

Costa, A. H., & Johnson, K. E. (2020, January). It's Not a Pipe Dream: Teaching Astronomy in Ways Students and Instructors Love and

that Develop Critical Thinking Skills. In *American Astronomical Society Meeting Abstracts# 235* (Vol. 235, pp. 202-06).

Demirci, F., & Özyürek, C. (2017). The effects of using concept cartoons in astronomy subjects on critical thinking skills among seventh grade students. *International Electronic Journal of Elementary Education*, *10*(2), 243-254.

Deniş Çeliker, H. (2012). *Fen ve teknoloji dersi "güneş sistemi ve ötesi: uzay bilmecesi" Unitsinde proje tabanlı öğrenme uygulamalarının öğrenci başarılarına, yaratıcı düşünmelerine, fen ve teknolojiye yönelik tutumlarına etkisi* [The effect of project-based learning practices on student achievement, creative thinking, and attitudes towards science and technology in the "solar system and beyond: space riddle" Unit of science and technology course]. (Unpublished doctoral thesis). Dokuz Eylül Üniversitesi, İzmir.

Durmaz, A. (2014). *Sosyal bilgiler derslerinde etkinlik uygulamalarının öğrenci motivasyonuna etkisi* [The effect of activity practices on student motivation in social studies lessons]. Muğla Sıtkı Koçman Üniversitesi, Muğla.

Facione, P. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction (The Delphi Report).

Göncü, Ö. (2013). *İlköğretim beşinci ve yedinci sınıf öğrencilerinin astronomi konularındaki kavram yanılgılarının tespiti* [Determining the misconceptions of the fifth and seventh grade primary school students about astronomy]. (Unpublished master's thesis). Mehmet Akif Ersoy Üniversitesi, Burdur.

Güçlü, İ. (2021). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in the social sciences]. Ankara: Nika Yayınevi.

Hannust, T., & Kikas, E. (2007). Children's knowledge of astronomy and its change in the course of learning. *Early Childhood Research Quarterly*, *22*, 89-104.

Heafner, J. (Ed.). (2015). Bringing critical thinking into introductory astronomy. *The Physics Teacher*, *53*(4), 250-250.

Herfana, P., Nasir, M., & Prastowo, R. (2019, November). Augmented Reality Applied in Astronomy Subject. In *Journal of Physics: Conference Series* (Vol. 1351, No. 1, p. 012058). IOP Publishing.

Karagöz, Y. (2021). *SPSS ve AMOS uygulamalı nicel-nitel-karma bilimsel araştırma yöntemleri ve yayın etiği* [SPSS and AMOS applied quantitative-qualitative-mixed scientific research methods and publication ethics]. Ankara: Nobel Yayıncılık.

Karakuş, E. (2009). A Systematic Review of the Representation of Cultural Elements in English as a Foreign Language Textbooks. *Language Teaching and Educational Research*, *4*(1), 13-29.

Karasar, N. (2012). *Bilimsel araştırma yöntemi* [scientific research method]. Ankara: Nobel Yayıncılık.

Kurnaz, M., & Değermenci, A. (2011). Sınıf seviyelerine göre temel astronomi kavramlarına ilişkin öğrenci algılamalarının karşılaştırması [Comparison of student perceptions of basic astronomy concepts by grade level]. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *1*(22), 91-112.

MEB. (2018). Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7, 8. sınıflar) [Science lesson curriculum (primary and secondary school 3, 4, 5, 6, 7, 8th grades)]. Ankara: Talim Terbiye Kurulu Başkanlığı.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded Sourcebook*. Thousand Oaks, CA: Sage.

Nosich, G. M. (2012). *Eleştirel düşünme ve disiplinlerarası eleştirel düşünme rehberi* [A guide to critical thinking and interdisciplinary critical thinking]. Ankara: Anı Yayıncılık.

Öztürk, E., & Razgatlıoğlu, M. (2013). 5. sınıf Türkçe ders kitaplarının eleştirel düşünme açısından incelenmesi [Examining 5th grade Turkish textbooks in terms of critical thinking]. *International Journal of Human Sciences*, *10*(1), 445-458.

Paul, R., & Elder, L. (2019). *Critical thinking: Tools for taking charge of your learning and your life*. Boston MA: PEARSON.

Reed, S. E., Kreylos, O., Hsi, S., Kellogg, L. H., Schladow, G., Yikilmaz, M. B., ... & Sato, E. (2014, December). Shaping watersheds exhibit: An interactive, augmented reality sandbox for advancing earth science education. In *AGU Fall Meeting Abstracts* (Vol. 2014, pp. ED34A-01).

Ridlo, Z. R., Dafik & Nugroho, C. I. W. (2020, June). The effectiveness of implementation research-based learning model of teaching integrated with Cloud Classroom (CCR) to improving critical thinking skills in an astronomy course. In *Journal of Physics: Conference Series* (Vol. 1563, No. 1, p. 012034). IOP Publishing.

Sönmez, V. (2012). *Program geliştirmede öğretmen elkitabı* [Teacher's handbook on curriculum development]. Ankara: Anı Yayıncılık.

Taufiq, M., Wijayanti, A., & Yanitama, A. (2020). Implementation of blended project-based learning model on astronomy learning to increase critical thinking skills. In *Journal of Physics: Conference Series* (Vol. 1567, No. 4, p. 042049). IOP Publishing.

Trumper, R. (2006). Teaching future teachers basic astronomy concepts-sun-earth moon relative movements at a time of reform in science education. *Research in Science & Technological Education*, *24*(1), 85-109.

Tuncer, B. (2017). *Okul öncesi dönemde eleştirel ve yaratıcı düşünme becerilerini etkileyen temel faktörler* [The main factors affecting critical and creative thinking skills in preschool period]. (Unpublished master's thesis). Yıldız Teknik Üniversitesi, İstanbul.

Uçar, R., & Aktamış, H. (2019). Astronomi'ye yönelik tutum ölçeği ve 7. sınıf "güneş sistemi ve ötesi" Unitsine yönelik başarı testi geliştirme çalışması [Attitude scale towards astronomy and achievement test development study for the 7th grade "solar system and beyond" Unit]. *Batı Anadolu Eğitim Bilimleri Dergisi*, *10*(1), 57-79.

Yıldırım, A., & Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in the social sciences]. Ankara: Seçkin Yayıncılık.