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Mathematical Values in Turkish High School Mathematics Textbooks*

Damla Ceren Bakırcı[1], Abdullah Çağrı Biber[2]

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Abstract

This study aims to examine how mathematical values are represented in Turkish high school mathematics textbooks during the 2019-2020 academic year. A case study design was used in this study. The research examined a total of 2175 questions. Descriptive analysis was used in the analysis of qualitative data. The data was sorted into mathematical value pairs. Three complementary pairing of mathematical values are considered: rationality-objectivism, control-progress, and openness-mystery. As a result of the analysis, it has been determined that the rationality-objectivism value pair is similar across all grade mathematics textbooks. The control value was also emphasized more than the progress value The openness value was highlighted more than complementary pairs of mystery values at the 9th, 10th, and 11th-grade levels. In comparison, the mystery value is emphasized more than the openness value in the 12th-grade textbook. As a result, it would be advisable to pay attention to the balanced distribution of complementary value pairs when considering the importance of mathematics values for mathematics textbooks.

Keywords: High school, mathematics textbooks, mathematical values, Turkey

1. Introduction

Values are the principles that lead or guide behaviors (Halstead & Taylor, 2000; Matthews, 2001). Clarkson and Bishop (2000) consider values as beliefs in actions. The belief that 'math is fun' reflects a judgment about mathematics. On the other hand, being 'fun' expresses a value (Bishop, Seah & Chin, 2003). Mathematics is seen as an abstract science that contains only logical inferences and does not contain any emotion. According to this view, mathematics has no value, that is, it is neutral (Ernest, 1991). However, mathematics also carries values and is not neutral. Therefore, mathematical values express the principles that determine the beliefs about mathematics (Clarkson, Bishop, FitzSimons & Seah, 2000). In mathematics education, mathematical values are defined as the set of affective qualities produced and developed by researchers from different cultures. Culture is an important marker for mathematical values. Even if the curricula are the same, the values adopted by the teachers trained in different geographies may be different. The values reflect the essence of mathematical understanding (Bishop, FitzSimons, Seah & Clarkson., 1999).

* Bu makale birinci yazarın yüksek lisans tez çalışmasından üretilmiştir.

[1] Doktora Öğrencisi-Öğretmen, MEB-Kastamonu, 0000-0002-8668-7792, drcerenbakirci@gmail.com

[2] Prof. Dr., Kastamonu Üniversitesi, 0000-0001-7635-3951, acbiber@kastamonu.edu.tr

Tapsir, Pa, Azis, and Zamri (2017) relate mathematical values to social behaviors and actions and divide them into three categories: Ideological, emotional, and sociological values. Sam and Ernest (1997) divided values specific to mathematics and mathematics education into three categories: epistemological, social, cultural, and personal values. Bishop (1996) categorizes these values as general educational, mathematical, and mathematical educational values. General educational values are associated with the norms of society and education in that society. In general, they include ethical values such as moral behavior, integrity, obedience, kindness, and modesty. Mathematical values refer to the qualities of the various mathematical disciplines. Values in mathematics education refer to the directive disciplines reflected in mathematics instruction in the classroom and to the norms of officially executed institutions. Bishop (2001) categorizes mathematical values in three parts as complementary pairs: rationalism-objectivism, control-progress, and openness-mystery. Since this research was carried out according to the classification made by Bishop (2001), it would be useful to introduce the components. This study was carried out by considering the classification made by Bishop (2001). Therefore, it is necessary to explain the components included in the classification.

Rationalism value is the most fundamental value among mathematical values. Turkish Language Society (TDK) (2020) states that the word rational means based on the mind, measured, calculated, and reasonable. The reason, logical analysis is emphasized based on rationalism value (Bishop, 1996). The indicator of rationalism values encourages students to argue and stimulate debate in the class. Furthermore, it means emphasizing proof show questions of evidence from different mathematical. It invites individuals to think analytically (Siahaan, 2020).

Objectivism value means emphasizing objectifying, symbolizing, and applying the ideas of mathematics (Bishop, 1996). Mathematics uses the value of objectivism in concretizing abstract ideas. The indicators of objectivism value in the textbook are to encourage students to use their symbols and terminology before somebody shows the truth (Siahaan, 2020). For example, mathematical symbols (letters, numbers, diagrams, figures) enable people to understand and analyze abstract concepts as objects (Bishop et al., 2003). While solving problems, using geometric drawings in some questions also related to objectivism values.

Control value means the mathematical value that relates to mathematical knowledge and has rules, facts, operations, and established criteria (Bishop, 2008). The control value is emphasizing mathematical knowledge through the rules, and procedures. In control, value includes examples and problems with imperative sentences that each question must be solved using a method (Dede, 2006a). The pair value of the control is the progress value which means the evaluation of definitions, algorithms, axioms, and proofs inherent in mathematics (Bishop, 1991). The process value emphasizes the growth of mathematical ideas tough alternative theories, and the development of new methods challenging eating ideas. Alternative and non-routine solution strategies emphasize their justification in in-progressive. It involves questioning existing ideas for the growth and development of mathematical and scientific thought. Developing, abstracting, and generalizing these ideas, developing alternative solutions, and talking about the stories of mathematical development in history are all parts of the progress value (Bishop, 2008).

Openness value means emphasizing the democratization of knowledge through evidence, reasoning, and individual explanation. The openness value is encouraging students to defend their ideas and answers to create posters, math bulletins, or web pages that they can easily express for themselves in front of the class (Bishop, 2008). In this value, the student's self-potential needs to be developed. The pair value of openness is mystery value means emphasizing mathematical imagination-based paintings, artwork, mathematical puzzles, riddles, and infinity pictures. It emphasizes the curiosity, magic, and mystery of mathematical ideas. Although individuals always think that mathematics knowledge is accessible and open, they have the notion that its abstract

nature is mysterious (Bishop, 1991). For example, the teacher discusses anecdotes of how people discovered zero or negative numbers in the past, and how the number pi can be used to demonstrate the importance of mystery by dividing by the diameter of each circle (Bishop, 2008). When preparing textbooks, all the values must be taken into account.

Each course contains its value therefore the values are critical for the progression of the course (Dede, 2006a). It has not been considered that mathematics education is taught in affective and emotional subjects as much as language, literature, physical education, and music education in the educational system. Values are the most important element to improve the quality of learning and teaching in mathematics (Lee & Cockman, 1995). Mathematical values significantly affect students' choices to deal with mathematics or not (Bishop, 2001; FitzSimons, Seah, Bishop & Clarkson, 2001). Cockcroft (1982) also argued that values are essential in mathematics education to inspire a desire to learn. In addition, values prove to be an important emotional factor influencing mathematics learning (Dede, 2006b). Mathematical values influence components of cognition, emotion, and behavioral inclination (Tavşancıl, 2002).

The textbooks are essential for learning mathematical knowledge (Altun, 2008). Furthermore, math textbooks make it possible to achieve the desired goals in education as quickly as possible. They are the most preferred instructional materials by teachers (Haggarty & Pepin, 2002; Johansson, 2003; Pepin, 1999). Therefore, textbooks allow students to develop themselves by allowing them to review, consolidate, and organize their knowledge (Issitt, 2004). For this reason, the textbook should hold the student's attention. All these contents of textbooks are related to the mathematical values in these books (Seah & Bishop, 2000). Textbooks, which occupy an important place in education and training, are the most valuable tools for designing, teaching, and developing mathematics and mathematical educational values (Amit & Fried, 2002; Johansson, 2003). The proportion of mathematical values in textbooks is a topic worthy of research.

In the mathematics education literature, some studies examine mathematical values and implement mathematics values in textbooks. Dede (2006a) investigated the mathematical values and mathematics pedagogical values in 9th, 10th, and 11th-grade thematic textbooks. Özenç (2019) investigated the mathematical values emphasized in 5th, 6th, 7th,d8 h-gradee mathematics textbooks. Yıldız (2019) studied the texts and pictures in the 5th, 6th, 7th, and 8th-grade middle school mathematics textbooks. Seah and Bishop (2000) studied 7th and 8th-grade mathematics textbooks. Cao, Seah, and Bishop (2006) studied the mathematical values reflected in secondary mathematics textbooks in China and Australia for two countries. In the mathematics education literature, studies are usually about secondary school textbooks. Therefore, this study aims to examine how mathematical values are included in the high school mathematics textbooks used in Turkey. For this purpose, the problem sentence of the study is “How and to what extent are mathematical values included in high school mathematics textbooks are used in Turkey?”.

2. Methodology

2.1. Research Design

This study is a case study. Case studies are studies in which detailed information about a situation is collected, the situation is described and themes are revealed (Creswell, 2016; Merriam, 2013). In this study, considering the classification made by Bishop (2001), it is investigated how mathematical values are included in high school mathematics textbooks.

2.2. Research Group

Turkish high school mathematics textbooks were discussed in this study. The sample of the study has been determined as the explanations, solved, and unresolved examples in the mathematics textbooks used in high schools in the 2019-2020 academic year. A total of 2175 questions were examined in the research. The details were given in Table 1. These books were given the codes M9, M10, M11, and M12 for the 9^{th}, 10^{th}, 11^{th}, and 12^{th} grades, respectively. The books were named with these codes throughout the study. Among the analyzed books are, 9^{th}-grade grade textbooks from MEB, the 10th grade textbook from Aydın Publications, the 11th grade textbook from Top Publishing, and the 12th grade textbook from Tutku Publications. Detailed information about the books analyzed in the study can be found in Table 1. Those textbooks are mandatory math textbooks by MEB in Turkish high schools in the 2019-2020 school year.

Table 1. Information on Textbooks

Grade	Publishing	publisher	Code	Page Number	Questions
9	MEB	2017	M9	376	569
10	Aydın	2019	M10	308	780
11	Top	2018	M11	352	524
12	Tutku	2019	M12	305	302

2.3. Data Gathering

In this study, a document analysis technique was used to collect data. This technique can be used alone or in conjunction with other data collection techniques in qualitative research (Yıldırım & Şimşek, 2016). In the study, a question analysis form created by the researcher was used as a data collection tool. In this form, there are titles such as "code of the textbook", "page number" of the question being examined, the title of the relevant "unit" and the "mathematical value" of the question. In this way, 569 samples from the 9th-grade textbook, 780 samples from the 10th-grade textbook, 524 samples from the 11th-grade textbook, and 302 samples from the 12th-grade textbook were examined.

2.4. Data Analysis

In this study, descriptive analysis was used to examine the textbooks. Here, the analysis consists of four stages. In the first stage, the researcher created a framework for data analysis from the conceptual framework of the research and literature reviews. In the descriptive analysis, data is analyzed according to predetermined themes. Here, the data were categorized as mathematical value pairs as given in the literature (Bishop, 2001). Then, the researcher read, organized, and digitized the data based on this framework. During the reading of the data, three different researchers were assisted for the reliability of the study. After this stage, the researcher defined the data he has organized. At the end of this process, the researcher explained, related, and made sense of the findings he has defined. At this stage, the researcher explained the cause-effect relationships between the findings to further strengthen his comments.

Bishop (2001) divided mathematical values into three parts as complementary pairs, Rationalism-Objects, Control-Progress, and Openness-Mystery. The questions in the books were analyzed by taking into account some indicators of mathematical values. According to this, the value of rationalism includes lectures, and questions that show cause-effect and contain logical conjunctions that include action-reaction, such as "accordingly, therefore, then, because ...". In the objectivism value, textbooks include shapes, models, graphs, symbols, and diagrams that embody the abstract. On the other hand, the control value includes statements that do not free the

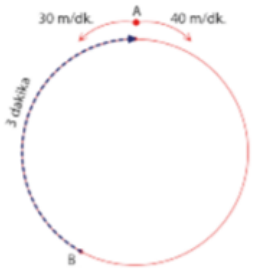
student, and contain imperative sentences, and questions to develop basic drawing skills. Progress value includes examples that liberate the student by asking the student to develop alternative approaches and remind the student of prior learning by paying attention to the student's readiness. Openness values include expressions such as explaining, commenting, or discussing creating a conflict of opinion that makes it easier for students to express their thoughts clearly. While simple examples that students can perform are assessed under the openness value, difficult and complicated examples, unexpected insights, surprising stories, exercises, and problems that represent mysteries and surprises of mathematics are examined under the mystery value (Bishop, 2001).

Below are examples of how coding is done while analyzing the data.

The distance of the 10-meter ladder from the wall is 6 meters. If the part of the ladder leaning against the wall is lowered a little, the part on the ground level also goes backwards by the same amount. The final state of the ladder is drawn in the figure. Find the value $\sin \alpha$ according to the given.

Figure 1. Example of Objectivism Value from MEB 9th Grade Textbook (P. 307)

Figure 1 includes an example of objectivism value in the 9th-grade mathematics textbook. It concretizes the figure and the situation to see the angle between the wall and the staircase for right triangles and trigonometry. For this reason, the question is included in the objectivism value.



Example: Their speed on a circular track is 30 m/min. and 40 m/min. Two cyclists ride simultaneously from the same point in opposite directions. If these two cyclists continue their way without stopping after they have met, the faster cyclist will return to the starting point after 3 minutes. Determine the length of the circular path in meters.

Solution: If the in the task is given as in the figure B faster than the bicycles meeting at point B from A to 40 m/min. B because he is going fast in 3 minutes. The distance between A and A is 40 . 3 = 120 m. from A to 30 m/min fast moving cyclist when B arrives to 120 30 4 | = in minutes. This until the faster cyclist meets the other, 4 minutes pass and 3 minutes after the encounter A has reached the point. Accordingly, the total is 4 + 3 = 7. He has moved for minutes. This gives the length of the runway 7. It is determined as 40 = 280 meters.

Figure 2. Example of Rationality value from MEB 9th Grade Textbook (P. 177)

Figure 2 includes an example of the value of rationality in the 9th-grade book. This example is about equations. The presence of cause-and-effect expressions such as "therefore, accordingly" in the question. So, it is about rationality value.

$f: R \to R$ *and* $g: R \to R$ *are the function,*

$f(x) = 2x - 4$ *and* $(fog)(x) = \frac{3x}{x^2-1}$

Then find the value of $g(2)$?

Let's $g(2) = m$,

$(fog)(x) = f[g(x)]$ *and for* $x = -2$,

we obtained $f(m) = -2$.
Supplying the value of $f(x)$ *is equai to* 2,
$f(x) = 2x - 4 \to f(m) = 2m - 4$ *and we know that* $f(m) = -2$.
we obtained
$2m - 4 = -2 \to m = -1$. *So we find* $m = g(-2) = -1$.

Figure 3. Example of the Control Value from Aydın 10th Grade Textbook (P. 86)

Figure 3 includes an example about a topic of functions, and it is about control value. Because the statements that guide the student and what he should do are stated step by step.

$f: R \to R$ *and* $g: R \to R$ *are the function,*

$f(x) = 3x + 1$ *and* $g(x) = x^2 - 1$
so calculate the value of $(fog)(-1)$?

First way

Find the rule of fog

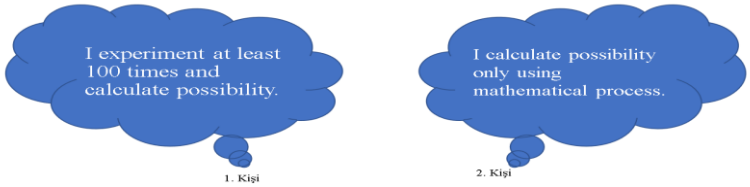
$$(fog)(x) = f[g(x)]$$
$$= f(x^2 - 1)$$
$$= 3(x^2 - 1) + 1$$
$$= 3x^2 - 2$$

So, we find $(fog)(-1) = 1$.

Second way
Let's do the solution without finding the rule of (fog)
$f(x) = 3x + 1$ *and* $g(x) = x^2 - 1$
$$(fog)(-1) = f[g(-1)]$$
$$= f[(-1)^2 - 1]$$
$$= f(0) = 3.0 + 1 = 1.$$
Then we obtained
$(fog)(-1) = 1$.

Figure 4. Example of Progress Value from Aydın 10th Textbook (P. 84-85).

Figure 4 includes an example of functions topic in the progress value. Because it shows alternative ways to solve the problems.

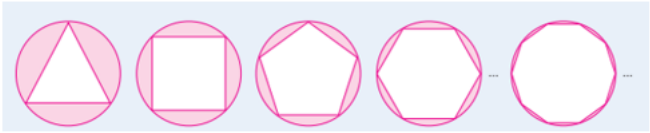


This possibility discusses the direction of calculation. Describe the possibilities you have determined in the situation you encounter in daily life and how you calculate and decide them.

Figure 5. Example of Openness Value from Top 11th Grade Textbook (P. 336)

Figure 5 includes an example of a question from the M11 book. In the example given on probability, the question was included in the openness value, as the expression "explain" which requires the students to express their ideas clearly and clearly, and the expression "discuss" to create a discussion environment by expressing their opinions mutually.

As shown in the following figures, we think that the triangle, square, proper pentagon, proper hexagon, ..., n are each properly adjacent to the circle of equal radius.



At each settlement, pay attention to the area between the circular spring and the beams. It is easy to see that n between the circle spring and the beam gets smaller as the number of edges increases. It will properly collapse polygon with n edges placed in the hoop for sufficiently large n value. Therefore, the circle will be obtained when the number of edges reaches the limit.

Figure 6. Example of Mystery Value from Tutku 12th Grade Textbook (P. 154)

Figure 6 contains an example of a question from the 12th-grade book. In this example, choose from the subject of 'Limit', the number of sides of the polygon that lies inside the circle is increased infinitely. In this way, it can be seen that it approaches the circle and thus the shape matches the circle. This was considered an unexpected insight for the student. Therefore, this example is included in the mystery value.

2.5. Validity and Reliability

Since the 2175 questions used in the research were quite a lot, only 300 randomly selected questions were given to three observers for analysis. In this way, it was aimed to ensure the compatibility of the observer analysis and the reliability of the research. As the researcher, these three observers are high school, mathematics teachers. Observers noted which mathematical value each question was closer to by taking notes on the question. The analysis process began after the observers learned the values and read the necessary information. The situation where the opinions about the questions were the same with the researcher was evaluated with "1", and the situation where they were different was evaluated with "0". The obtained data were analyzed using an online program that calculates the encoder reliability. The number of observers was greater than two in the analysis, so Fleiss' kappa coefficient was used. (Fleiss, 1971; Gordis, 2014). The obtained value of κ (0.849) shows that there is a very good agreement between observers (Landis & Koch, 1977). Therefore, it can be said that the reliability of the study is high.

2.6. Research Ethics

The ethical standards as specified by the APA were followed before and during the study. This research was conducted in the 2019-2020 academic year. For this reason, the study does not have an ethics committee document. Also, no living things were used in the study, data were collected only from mathematics textbooks used in schools in the 2019-2020 academic year.

3. Findings

The study examined the extent to which 9th, 10th, 11th, and 12th-grade mathematics textbooks reflected mathematics values. The findings obtained in the study were expressed as percentages for each textbook**.**

The graphic showing the proportion of the rationality and objectivity value in the questions of textbooks is given in Figure 7.

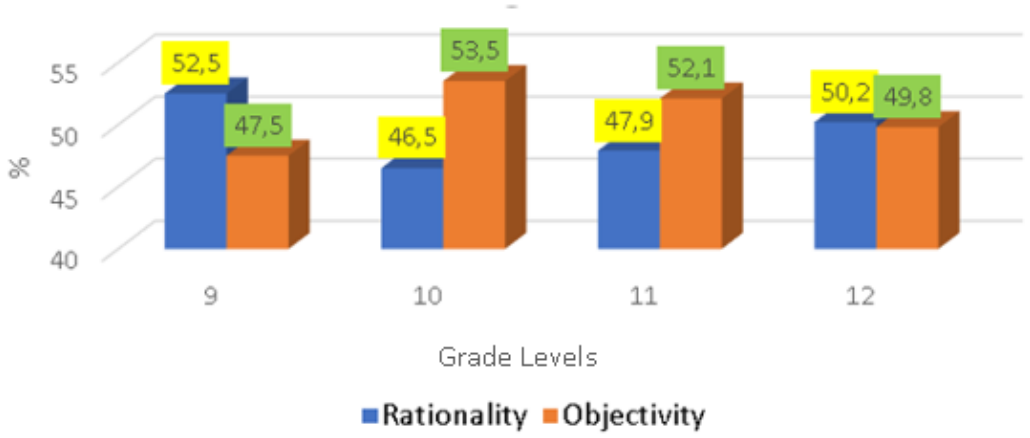


Figure 7. Rationality-Objectivity Values in Textbooks

According to Figure 7, it is seen that rationality (52.5%) is dominant in the 9th-grade mathematics textbook. In the 10th-grade mathematics textbook, it is understood that objectivism is the dominant value with a rate of 53.5%. It can be said that objectivism (52.1%) is ahead in the 11th-grade mathematics textbook. In the 12th-grade mathematics textbook, it is seen that there is a balanced distribution between both values.

The graph showing the proportion of the control-progress value in the questions of textbooks is given in Figure 8.

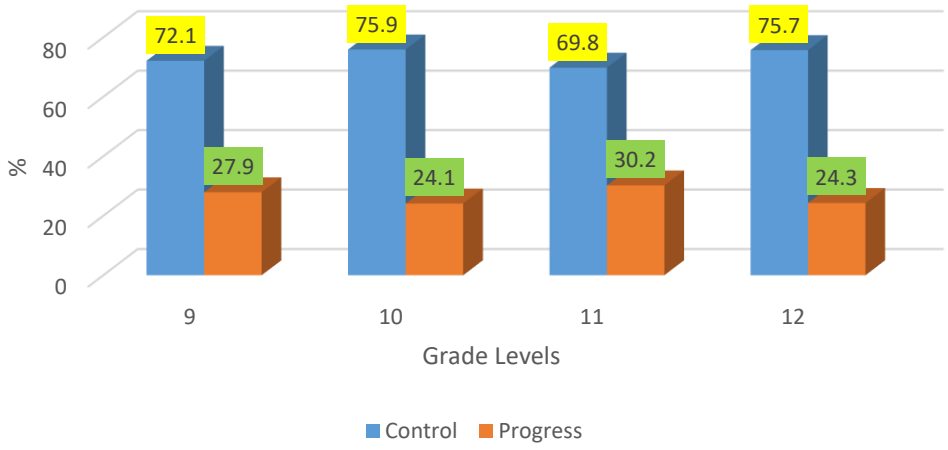


Figure 8. Control-Progress Values in Textbooks

According to Figure 8, the control value is dominant in the 9th grade (72.1%), 10th grade (75.9%), 11th grade (69.8%), and 12th-grade mathematics textbooks (75.7%) seem to be.

The graph showing the proportion of the openness-mystery value in the examples in the textbooks is given in Figure 9.

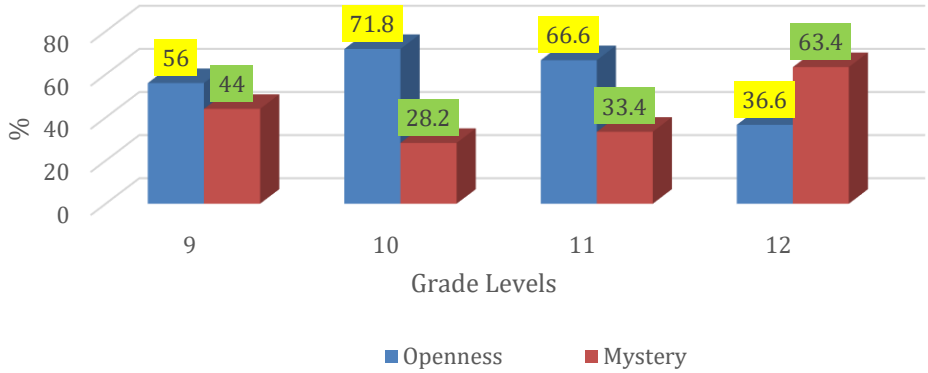


Figure 9. Openness-Mystery Values in Textbooks

According to Figure 9, it is seen that the value of openness is prominent in the 9th grade (56%), 10th grade (71.8%), and11th-gradee mathematics textbooks (66.68%). In the 12th-grade mathematics textbook (63.4%), it is seen that the value of mystery is dominant. It can be said that these two values have a more balanced distribution in the 9th-grade mathematics textbook.

4. Discussion, Conclusion, and Suggestions

This research was investigated the content of the mathematical values in high school textbooks used in Turkey during the 2019-2020 school years. The textbooks are contained three pairs of mathematical values such as rationalism-objectivism, control-progress, and openness-mystery.

In this research, it is seen that rationality (52.5%) is dominant in the 9th-grade mathematics textbook. In the 10th-grade mathematics textbook, objectivism is the dominant value with a rate of 53.5%. In the 11th-grade mathematics textbook, objectivism (52.1%) is ahead. In the 12th-grade mathematics textbook, it is seen that there is a balanced distribution between both values. In summary, the rationality-objectivism value pair was close to each other in all grade levels. It is thought that the value of objectivism is emphasized more in the 10th and 11th grades because these classes mainly include geometry subjects. Mathematics can be considered as the abstraction of life. Therefore, learning mathematics is difficult for students (Durmuş, 2004). It is important to use concrete and illustrative materials in teaching mathematics to materialize abstract knowledge (İnan, 2006; Kutluca & Akın, 2013). For this reason, it is considered positive that the value of objectivism is included in the books at these rates. In this way, the fact that the complementary value pairs are close to each other is evaluated as positive. The results of this study showed some similarities and discrepancies with Dede's (2006a) research. Dede (2006a) examined the mathematical values in the 9th, 10th, and 11th-grade secondary school mathematics textbooks. 12th-grade textbooks have not been examined. In this study, the objectivism mathematical values were emphasized more than rationality in the 10th and 11th-grade textbooks, s and mystery values were emphasized more than openness values in the 12th-grade book. In addition, according to Özenç's (2019) study, the value of objectivity is more prominent at some grade levels, as in this study. Seah and Bishop (2000) et al. examined that it was seen that the objectivism, control, and mystery mathematical values were emphasized more than their

complementary values in the 7th and 8th-grade textbooks in Singapore and Victoria. In the same study, the objectivism value was taken more place than the complementary value of rationality value in all books but was seen only in the 10th and 11th-grade textbooks. In this study, the control value was emphasized more than the progress value at all grade levels, which is similar to Seah and Bishop's (2000) findings.

The control value was emphasized more than the progress value in all grade textbooks. The control value is dominant in the 9th grade (72.1%), 10th grade (75.9%), 11th grade (69.8%), and 12th-grade mathematics textbooks (75.7%). The control value emphasizes rules, procedures, and the application of criteria. It provides the solution with instructions that do not free the student. Valuing progress means emphasizing, as, in the constructivist approach to education used today, students are free in the learning process. The students solve the problem by developing alternative ways. This is necessary so that the students can select their methods when faced with similar issues. Progress value emphasizes developing alternative methods and the question of existing ideas about mathematic knowledge. Due to its importance, it can be said that the value of progress should be given more place in the textbooks. Özenç (2019) examined the mathematical values in the 5th, 6th, 7th, and 8th grades. Similarly, in Özenç's (2019) study, it was emphasized that the control value was more dominant in textbooks.

The openness value was emphasized more than the mystery value in 9th, 10th, and 11th-grade textbooks. In the 12th grade textbook, the mystery value was placed more. The openness value means emphasizing discussion and analysis of mathematical proofs, ideas, results, and arguments (Seah & Bishop, 2000). Students are encouraged to express their ideas in the classroom. As a result, students can develop alternative methods and realize the universality of mathematical knowledge that is not dependent on time, place, or person (Bishop, 1991). Therefore, the value of openness should be emphasized in textbooks. However, the difference between the openness value and the mystery value pair is high in the 10^{th}-graduate book. Mystery value means the mysterious, attractive, and surprising aspect of mathematical knowledge (Bishop, 2008). The unexpected insights and connections inherent in mathematics are represented by this value. The mystery value provides students to maintain a positive attitude toward mathematics learning. More emphasis can be placed on the mystery value in books by increasing the number of mathematical puzzles and engaging visuals to engage students' curiosity. In addition, more emphasis should be placed on openness value in 12^{th}-grade mathematics textbooks. For this purpose, questions can be added to the textbooks where the pupils can freely express their ideas. In this way, the pairs of values will be distributed more evenly throughout the class. The research Cao et al. (2006) examined in China-Australian mathematics textbooks convey mathematics values. Cao et al. (2006) showed that objectivism, control, and mystery mathematical values were emphasized more than rationalism, progress, and openness in both countries' mathematics textbooks. Besides, Cao et al. (2006) found that the openness value is less emphasized than the complementary mystery value at all grade levels, the openness value was emphasized more in Turkish textbooks, except for the 12th-grade book. Also, although similar values were revealed in the textbooks, there were differences in the teaching of values. Moreover, the mystery value was more emphasized in Seah and Bishop's (2000) study, the mystery value is more placed in this study only in the 12th-grade textbook.

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Research Ethics

The ethical standards as specified by the APA were followed before and during the study. This research was conducted in the 2019-2020 academic year. For this reason, the study does not have an ethics committee document. Also, no living things were used in the study, data were collected only from mathematics textbooks used in schools in the 2019-2020 academic year.