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An examination of the activities in 8th grade mathematics textbooks based on the levels of cognitive demand[1]

Ali Bozkurt, *Gaziantep University*, Turkey, *alibozkurt@gantep.edu.tr* ORCID: 0000-0002-0176-4497
Şerife Yılmaz, *Gaziantep University*, Turkey, *serife1284@gmail.com* ORCID: 0000-0002-6907-7650

Abstract: In this study, the cognitive demand levels of the activities in 8th grade mathematics textbooks were attempted to be identified and the distribution of these textbooks was compared based on the cognitive demand levels of the activities. The method used in the research was document analysis. In order to collect the data, a total of 90 activities in two 8th grade mathematics textbooks approved by the Education Board of the Ministry of National Education were examined. A descriptive analysis method was used to analyze the data. Findings of the study demonstrated that the number of activities in both textbooks approximated to each other. Although the reviewed textbooks were approved by the Board of Education as textbooks, it was observed that the cognitive demands of the activities provided concentrated on levels that are connected and are unconnected to procedures and that the textbooks demonstrated a differentiation based on cognitive demand levels when compared to each other. In this respect, students educated with different textbooks may have different learning outcomes.

Keywords: Activity-based teaching, mathematical activities, cognitive demand levels

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INTRODUCTION

In the constructivist approach, the teacher is described as the person who leads students to think, who guides them, increases their motivation and makes assessments and works together with them (Savery & Duffy, 1995). One of the recommended tools for providing a constructivist environment is the teaching activities. One must be careful with the selection, structure, planning and implementation of activities so as to allow students to learn topics through thinking (Doyle, 1983; Hiebert & Wearne, 1993; Marx & Walsh, 1988; Yeo, 2007). The choice or design of the appropriate activities and the process for applying these activities are important in revealing desired student roles.

It can be seen that there are different types of activities that can be evaluated differently in the related studies. Teaching activities can be categorized in many different aspects, such as application areas (Olkun & Toluk Uçar, 2009; Wasserman, Davis & Astrab, 2007), design and implementation objectives, aspects of teaching (Swan, 2008), the relationship of the activities with cognitive processes and levels of cognitive demand (Grandgenett, Harris & Hofer, 2011). Cognitive processes as well as mathematical competencies and skills are taken into consideration especially in the classification and determination of the type of mathematical activities (Özgen, 2017). Cognitive demands underscore the levels of thinking required during the performance of the activity. In a good activity, the age, grade level and preliminary information of students as well as classroom conditions and expectations from the activity should be taken into account in addition to the cognitive demands of the students (Stein and Smith, 1998). The level of thinking expected from students determines what students will learn (Hiebert et al., 1997). If student skills such as thinking, explaining and problem solving are to be improved, students need to encounter activities that require a high level of cognitive thinking (Stein and Lane, 1996). In this context, cognitive demand levels need to be determined in order to understand the extent to which the activities lead students to think (Engin & Sezer, 2016).

[1] This study is produced from the master thesis completed by the second author.

Activities by Cognitive Demand Levels

Stein & Smith (1998) classify activities in four categories according to their levels of cognitive demand; memorization, procedures without connections, procedures with connections and doing mathematics based on previous studies (Doyle 1983; Hiebert & Wearne, 1993; Marx & Walsh, 1988). Of these four categories, they classify memorization and procedures without connections as low-level and procedures with connections and doing mathematics as high-level activities. In activities at a memorization level, the student is often expected to provide a definition and some examples containing this definition. The activities at the level of procedures without connections are those for which the student will use their procedural skills related to rules that they will usually be able to remember without making any connections. In activities at the level of procedures with connections, students are expected to make connections with daily life and other learning areas of mathematics. Thus, students are expected to reach concepts and meanings by making a connection based on the concept included in the activity. In activities at the level of doing mathematics, an unstructured, i.e. an open-ended structure is provided. Students are expected to make connections with their daily lives or prior knowledge. These are the type of activities that are not explained clearly in their guidelines or require work beyond examples, including complex and non-algorithmic thinking and those requiring high-level thinking skills (Özgen, 2017; Stein & Smith, 1998).

Each mathematical activity is tailored to a specific level of cognitive demand and this level of cognitive demand determines what students will learn (Hiebert & Wearne, 1993). The level of cognitive demand is affected by many factors including the subject of the activity, its content, and the stage of the teaching course where it will be used. Sometimes the purpose of an activity is to enable the discovery of new knowledge while at other times it is to reinforce knowledge learned in the past (Romero, del Mar García & Codina, 2015). Different levels of activities can be included in the teaching process according to the level of cognitive demand. In fact, this balance of requirements may differ for students with high levels of success and students with low levels of success (Vincent & Stacey, 2008). The use of content-rich and mentally challenging activities in classroom teaching enables students to think mathematically, improve their logic and gain problem-solving skills (Stein & Lane, 1996; Stylianides & Ball, 2008). That is, the use of activities that require a high cognitive level of thinking in the learning environment provides more in-depth learning (Romero, del Mar García & Codina, 2015). In low-level activities, the student deals with routine problems which hinders the student's conceptual learning and blinds mathematical thinking (Henningsen & Stein, 1997). It is important for students to encounter high-level activities rather than low-level activities so that they can understand the mathematical concepts, connections and the nature of mathematics in a deeper and more creative way (Stein, Smith, Henningsen, & Silver, 2000; Ubuz & Sarpkaya, 2014). In addition, a teacher with effective teaching skills can easily increase the level of a low-level activity and, in the same way, some class conditions can easily lead to a fall in a high-level activity (Smith & Stein, 1998).

Textbooks

Textbooks are important materials that can be accessed and used at any time and are therefore frequently used in learning environments. A well-prepared textbook provides guidance in the teaching process (Haggarty & Pepin, 2002). Textbooks are primarily expected to contain methods and strategies that are compatible with the curriculum and also must be educative in terms of format and content (Bozkurt & Kuran, 2016). A textbook is considered to be of good quality only to the extent that students can benefit from it (Altun, Arslan, & Yazgan, 2004). The curricula prepared under the constructivist approach and the textbooks written in accordance with these programs are required to reflect the philosophy of this approach (Draper, 2002). Since textbooks serve as a bridge between the teacher and the students, they have an important place in education and are a frequently used teaching aid (Altun, Arslan & Yazgan, 2004). In addition, curricula that are prepared in line with a constructivist perspective are based on a student-oriented approach to develop high-level cognitive skills in students such as analyzing, comparing, interpreting, communicating, generalizing, and creative thinking, and the concept of activity is important in this approach (Aykaç, 2007). Teaching activities are among the most important tools that are expected to be used to demonstrate this approach. In this context, the selection of textbooks and the importance of the activities in the textbooks are also critical.

One of the most appropriate components to be exhibited by the curriculum in the learning environment, such as the ability to use cooperative learning, material usage and the ability to make mathematical inferences, is the teaching activity. In this context, since the activities included in the textbooks are a reflection of the philosophy of the curriculum, whether the activities are sufficient to provide a mathematical point of view or not and how much they lead students to think become important (Ubuz, Erbaş, Çetinkaya, & Özgeldi, 2010). A review of the studies related to textbooks reveals that there are many studies examining textbooks in terms of format, content, and teaching methods and strategies (Dane, Doğar & Balkı, 2004; Işık, 2008). When studies related to activities are reviewed, many studies are encountered dealing with the features that the activities should have (Bozkurt, 2012; Bukova-Güzel & Alkan, 2005; Collopy, 2003; Gömleksiz, 2005; Kerpiç & Bozkurt, 2011). It is possible to see the studies in the context of cognitive demand (Engin & Sezer, 2016; Reçber, 2012). However, the review of the studies reveals that there are not many studies comparing the cognitive demand levels of the activities in the textbooks. It is important to examine and evaluate the cognitive demand levels of the activities in textbooks in order to determine the adequacy and quality of the textbooks (Boston & Smith, 2009; Jones & Tarr, 2007; Ubuz, Erbaş, Çetinkaya & Özgeldi, 2010). The cognitive demand levels of the activities included in the textbooks are expected to affect the cognitive levels of the individuals to be taught. Individuals with a high level of cognition are effective problem solvers who can use appropriate strategies based on the situation and change their strategy where they consider it to be necessary (DeBaryshe, Patterson & Capaldi, 1993). In this respect, the study is expected to contribute to the literature and provide guidance in the preparation of textbooks.

Considering the importance of the cognitive demand levels of the activities in textbooks, the purpose of this study is to examine the activities in 8th grade mathematics textbooks based on their levels of cognitive demand and to compare the activities included in the two different textbooks in terms of their cognitive demand levels. In line with the purpose of the study, the answers to the following question are sought:

- What are the cognitive demand levels of the activities in the textbooks based on mathematics learning areas?
- How is the distribution of the activities in the examined textbooks based on their levels of cognitive demand?

METHOD

This study was designed as a document analysis. In studies where document analysis is performed, written texts relating to the research topic are analyzed (Yıldırım & Şimşek, 2008). As part of the document review, the activities included in two 8th grade mathematics textbook were examined. These are textbooks that were approved by the Board of Education for a teaching period of 5 years as of 2016. Both of these books as textbooks in the 2017-2018 academic year have been distributed to schools throughout Turkey. One of the books is used as a textbook in the school where the second author is a teacher. Since the main purpose for the examination of the books is not to reveal the deficiencies of the textbooks, they are coded as textbooks A and B instead of identifying their authors and publishers. Textbook A is 262 pages and includes 47 activities. Textbook B is 325 pages and includes 43 activities.

Data Analysis Process

The descriptive analysis approach was used to analyze the research data. According to this approach, the data obtained is summarized and interpreted according to a conceptual framework (Özdemir, 2010). In this context, each activity in the 8th grade mathematics textbooks (A and B) was analyzed using the framework for cognitive demand levels included in the study of Stein and Smith (1998). The level of thinking expected from students determines what students will learn (Hiebert et al., 1997). In this context, it was considered appropriate to use the theoretical framework put forward by Stein and Smith (1998) in determining the levels of cognitive demand in order to understand how the activities lead cognitively to students. In the context of this framework, activities were first categorized according to their low and high cognitive demand levels.

Low-level cognitive demands

Activities based on memorization and activities at the level of procedures without connections are categorized as activities at a low level of cognitive demands.

The Memorization level: Attributes of the activities at the memorization level are as follows (Stein & Smith, 1998):

- Such activities involve recalling previously learned information, rules, formulas or definitions.
- They cannot be solved using a method or a procedure since there is no method or procedure to be applied.
- They involve the repetition of previously learned information, rules, formulas or definitions. The information that needs to be repeated and what is asked to be done and created is clear. There are no uncertainties.
- They do not involve making connections with the underlying meanings of the procedures, rules, formulas or definitions that need to be repeated.

The activity number 36 in Textbook A was evaluated as being at this level (Figure 1).

ACTIVITY: **Application Steps**

- Write down the appropriate mathematical sentences for the statements provided below.
  - The number that Emel has in mind is less than 8: ....
  - The weather temperature is greater than 15°C: ....
  - The size of class 8 A is less than 34: ....
  - When an integer is multiplied by 3 and 1 is added to the resulting number, the number obtained is less than 13: ....
  - Those under 18 years old are not allowed: ....
- Explain the mathematical sentences you wrote to the class. Decide the correctness of these as a class.

FIGURE 1. *Example of the activity in Textbook A which is evaluated as being at the level of memorization*

In Figure 1, the activity in Textbook A involves recalling the information: "a statement written with one of the symbols $<, >, \leq, \geq$ is called an inequality". It involves the repetition of the previously learned inequality information. There are no uncertainties. It cannot be solved using a procedure since there are no procedures to be applied. In this context, this activity was evaluated as being at the level of memorization.

The level of procedures without connections: Attributes of the activities at the level of procedures without connections are as follows (Stein & Smith, 1998):

- Such activities involve algorithmic procedures. There is one procedure to be applied. The use of the procedure is expressly requested or is evident from prior education, experience or the location of the activity.
- Limited cognitive thinking is required to successfully complete the activity.
- There is little uncertainty about what is asked to be done or how it should be done.
- Instead of developing mathematical understanding, the activities are focused on finding the right answer by using the definitions and procedures.
- They do not involve making a connection with the underlying meaning of the procedure used nor with the concepts underlying the method.

Activity number 3 in Textbook B was included in the level of procedures without connections.

ACTIVITY: Square number in the table
Tools and Supplies: • pencil, • white cardboard, colored pencil

- Let's write the number table of 100 including numbers from 1 to 100 on our cardboard.
- Let's circle the square numbers in our table with our colored pencil.
- Let's write each number we circled as an exponential number.
- The number at the base of the exponential number is called the square root of the square number. For example, $9 = 3 \bullet 3 = 3^2$, then 3^2 is the square root of the number 9. The square root operation is shown using the "$\sqrt{a}$" symbol. Accordingly, $\sqrt{9} = 3$
- Find the square root of the square numbers using the given example.

FIGURE 2. *The example of the activity in Textbook B is evaluated as being at the level of procedures without connections*

In the activity in Textbook B (Figure 2), the student was asked to find the square roots of the numbers from 1 to 100 using the information: ''the number at the base of the exponential number is called the square root of the square number''. Such activities involve algorithmic procedures. The square root must be extracted. The student is focused on finding the right answer using information on the square root of integers and undertaking square root operations.

High-level cognitive demands

Activities at the level of procedures with connections and doing mathematics are categorized as activities at a high level of cognitive demands.
The level of procedures with connections: The attributes of activities at the level of procedures with connections are as follows (Stein & Smith, 1998):

- Students need to use procedures to understand mathematical concepts and ideas in depth. So, such activities suggest following the general concepts and the indirect means to the solutions to understand the underlying concepts of the general procedures, the conceptual thoughts and the incomprehensible algorithms underlying the concept.
- Generally, multiple representations (visual diagrams, manipulations, symbols and problem situations) are used. Making connections between multiple representations improves understanding.
- They require a specific cognitive effort.
- While they involve following general procedures, they do not involve following in an unconscious way without a process of thinking.
- Students need to think about the conceptual ideas together with the conceptual ideas based on the procedures for successful completion of the task and the consequent discovery of understanding.

Activity number 14 included in Textbook A can be provided as an example of activities evaluated as being at the level of procedures with connections (Figure 3).

ACTIVITY: Application Steps

- Multiply the number $\sqrt{20}$ provided in the table on the right with other square roots.

X	$\sqrt{1}$	$\sqrt{2}$	$\sqrt{5}$	$3\sqrt{5}$	$\sqrt{10}$	$\sqrt{20}$
$\sqrt{20}$						

- According to the results you find, state the multipliers that make the result a natural number.
- Explain your idea of multipliers that make a square root expression a natural number.

FIGURE 3. *An example of the activity in Textbook A which is evaluated as being at the level of procedures with connections*

In Figure 3, in the activity in Textbook A the expression of finding multipliers resulting in natural numbers is attempted to be reached through operations that require multiplication of square root expressions. In other words, there is a connection between the multipliers that makes the square root a natural number through the multiplication operations in square root expressions. Students need to perform the general procedures to understand the deeper mathematical relationships. In such an activity, the student makes a connection between the multiplication operations through the square root expressions they obtain and associate it with the idea that the multipliers resulting in natural numbers are those that can turn the expression of the square root into a square number. This association requires a cognitive effort. In this context, the activity was evaluated as being at the level of procedures with connections.

The level of doing mathematics: Attributes of activities at the level of doing mathematics are as follows (Stein & Smith, 1998):

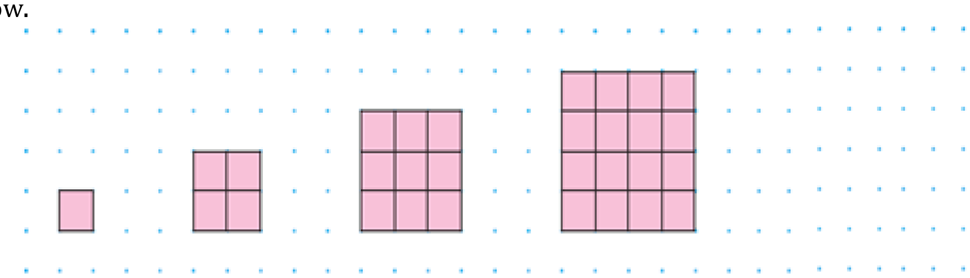
- Such activities involve complex and non-algorithmic considerations (which are not explicitly stated in the guidelines or which require work beyond examples).
- They require students to understand and explore the nature of mathematical concepts, processes or relationships.
- They involve students' monitoring of their own cognitive domains and organizing their cognitive processes.
- They require students to use appropriate working methods to access and discover information.
- Students should analyze the work by analyzing the limitations, the strategies with possible solutions and the solutions.
- They require significant cognitive effort.
- As the solution process has an unpredictable nature, it causes mental disorder and anxiety in students.

The activity number 9 included in Textbook A was evaluated as being at the level of doing mathematics (Figure 4).

ACTIVITY: Application Steps

Tools and Supplies: Dotted paper

- Quadratic regions with a length of 1, 2, 3 and 4 units on one edge are drawn on the dotted paper below.



- Examine the table below

One edge length of the quadratic region (unit u)	1	2	3	4	5	6
Area of the quadratic region	$1 \cdot 1 = 1$	$2 \cdot 2 = 4$	$3 \cdot 3 = 9$	$4 \cdot 4 = 16$	...	...

- Using the table, find the unit area of each quadratic region with an edge length of 5 and 6 units. Write down the unit areas you find on the table.
- Explain the relationship between the areas of the quadratic regions and the individual edge length of each of these quadratic regions.
- According to the table, if an edge length of the quadratic region is indicated by a, state how you can express the area of this quadratic region algebraically.
- When the pattern in the table is determined, indicate the units of the individual edge lengths of the quadratic regions with unit areas of 49, 64, 81.

FIGURE 4. *An example of the activity in Textbook A as being at the level of doing mathematics*

In the activity in Figure 4, quadratic regions are drawn and the areas of these regions are shown in a table. The student is expected to make a connection between the areas of these quadratic regions and the single edge lengths of these regions; generalize this connection and determine a general rule. It requires students to use appropriate working methods to access and discover information. They require significant cognitive effort. As the solution process has an unpredictable nature, it causes mental disorder and anxiety in students. In this context, the activity was evaluated as being at the level of doing mathematics.

Reliability Study

In this study, the researcher referred to one of the textbooks to be examined as Textbook A and the other one as Textbook B; examined each of the activities in these two textbooks based on their levels of cognitive demand; and organized the data with a scoreboard. Then, another scoreboard based on the levels of cognitive demand for the same activities was created independently of the researcher by another researcher who specializes in mathematics education. The tables created by the researchers were compared and activities that are "agreed on" and "disagreed on" were identified. If the two researchers determined the same levels of cognitive demand for the relevant activities, such activities were considered to be agreed on and if they determined different levels of cognitive demand the activities were considered to be disagreed on. The reliability of the study was determined using the formula by Bakeman and Gottman (1997) and the average reliability was calculated:

$$P(Percentage\ of\ compatibility) = \frac{Na(Agreed\ on)}{Na\ (Agreed\ on) + Nd(Agreed\ of)}$$

For Textbook A; the "percentage of compatibility" was found to be 80.8%. For Textbook B; the "percentage of compatibility" was found to be 88.3%. The ratios for these two textbooks are considered to be reliable (Miles & Huberman, 1994). Although the ratios obtained were considered to be reliable, the researcher who performed the data analysis and the other researcher specializing in mathematics education came together and reconsidered and discussed the activities that were disagreed on until a consensus was reached. For example, if researchers stated that they were at different levels for the same activity, the definitions and effectiveness of the relevant levels were re-read and a common decision was reached. Thus, the reliability of the data analysis was improved.

RESULTS

Findings on the distribution of the 90 activities included in the examined textbooks based on their cognitive demand levels are provided in Figure 5.

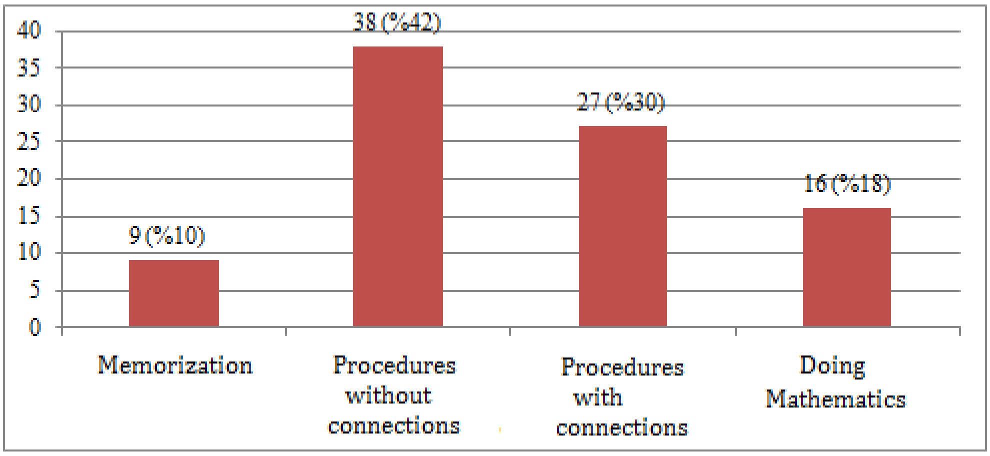


FIGURE 5. *Distribution of all activities in the examined textbooks based on their levels of cognitive demand*

When Figure 5 is analyzed, it can be seen that 9 (10%) of the activities in both textbooks are at the level of memorization; 38 (42%) are at the level of procedures without connections; 27 (30%) are at the level procedures with connections and 16 (18%) are at the level of doing mathematics. In another aspect, 52% of the activities in both textbooks are in the low-level category of cognitive demand, while 48% are in the high-level.

Findings on the distribution of the activities in each of the examined textbooks based on their cognitive demand levels are presented in Figure 6.

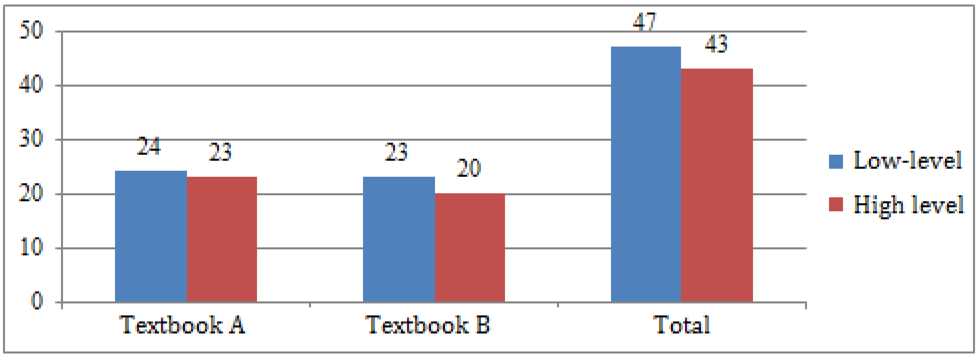


FIGURE 6. *Distribution of activities in the examined textbooks based on their low and high levels of cognitive demand*

When Figure 6 is examined, it can be seen that 24 of the 47 activities in Textbook A are in the low-level category, while the remaining 23 are in the high-level category. It can be seen that 23 of the 43 activities in Textbook B are in the low-level category, while the remaining 20 are in the high-level category. As can be seen in Figure 6, the number of low-level activities in textbooks A and B is close to the number of high-level activities.

Distribution of activities in each textbook based on their cognitive demand levels are presented in Figure 7.

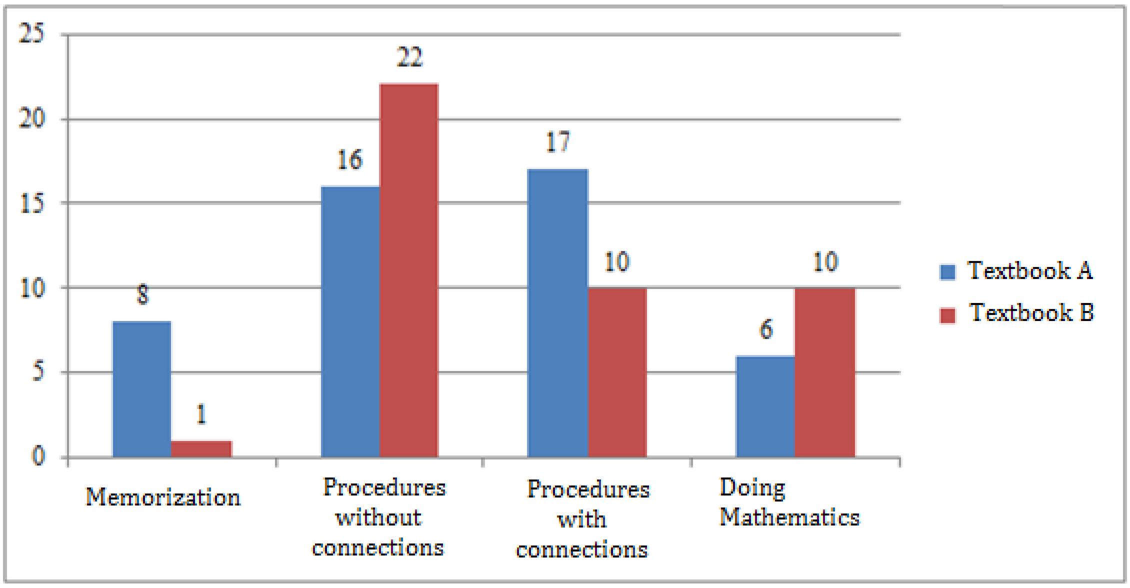


FIGURE 7. *Distribution of activities in each textbook based on their cognitive demand levels*

According to Figure 7, there are 8 activities in Textbook A and 1 activity in Textbook B that are on a memorization level. There are 16 activities in Textbook A and 22 activities in Textbook B that are on the level of procedures without connections. There are 17 activities in Textbook A and 10 activities in Textbook B that are on the level of procedures with connections. There are 6 activities in Textbook A and 10 activities in Textbook B that are on the level of doing mathematics.

The distribution of the activities in the textbooks according to the learning areas and the distribution of the activities in each learning area according to their cognitive demand levels are presented in Figure 8.

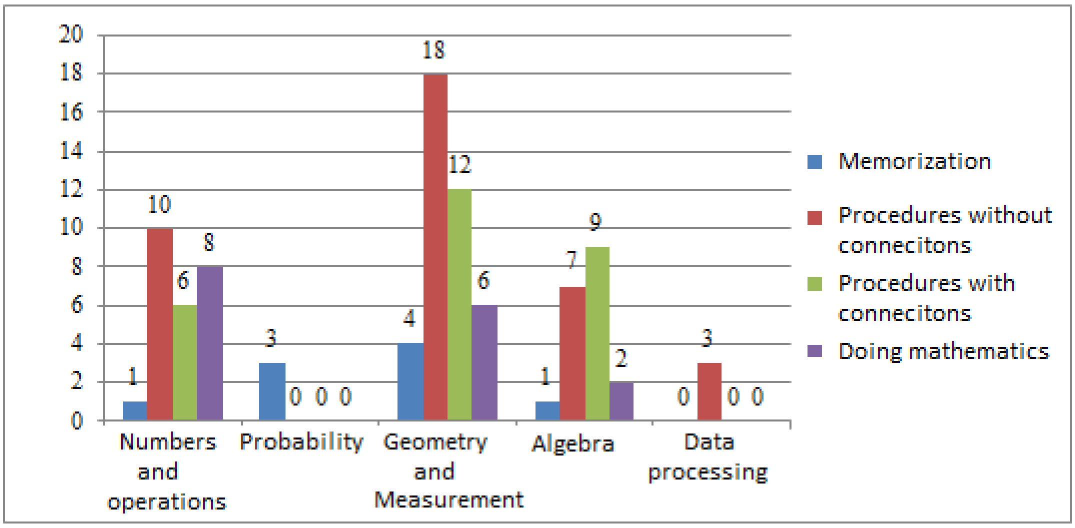


FIGURE 8. *Distribution of the cognitive demand levels of activities based on their learning areas*

When Figure 8 is examined, it can be seen that the learning area with the highest number of activities in the textbooks is geometry (40). In the textbooks, there are a total of 25 activities in the learning area of numbers and operations, 1 of which is on a memorization level, 10 are on the level of procedures without connections, 6 are on the level of procedures with connections and 8 are on the level of doing mathematics. All 3 activities in the learning area of probability are on a memorization level. In the learning area of geometry, there are a total of 40 activities, 4 of which are on the level of memorization, 18 are on the level of procedures without connections, 12 are on the level of procedures with connections and 6 are on the level of doing mathematics. In the learning area of algebra, there are a total of 19 activities, 1 of which are on the level of memorization, 7 are on the level of procedures without connections, 9 are on the level of procedures with connections and 2 are on the level of doing mathematics. All 3 activities in the learning area of data processing are on the level of procedures without connections.

The cognitive demand levels of the activities in textbooks A and B based on their learning areas are presented in Table 1 and Table 2.

Table 1. *Cognitive demand levels of the activities in Textbook A based on their learning areas*

	Number of gains	Memorization	Procedures without connections	Procedures with connections	Doing mathematics	Total
Numbers and operations	17	0	8	3	6	17
Probability	5	3	0	0	0	3
Geometry	17	4	4	8	0	16
Algebra	13	1	2	6	0	9
Data processing	2	0	2	0	0	2

When Table 1 is examined, it can be seen that the number of activities in the learning areas of probability, algebra and geometry is less than the number of gains, while the number of activities in the learning areas of numbers and operations and data processing are as much as the number of gains. While there are no activities in the learning area of numbers and operations on a memorization level in the textbook, there are a total of 17 activities, 8 of which are on the level of procedures without connections, 3 are on the level of procedures with connections and 6 are on the level of doing mathematics. All 3 activities in the learning area of probability are on a memorization level. Of a total of 16 activities in the learning area of geometry, 4 are on the level of memorization, 4 are on the level of procedures without connections and 8 are on the level of procedures with connections and there are no activities on the level of doing mathematics. In the learning area of algebra, there are a total of 9 activities, 1 of which is on the level of memorization, 2 are on the level of procedures without connections, 6 are on the level of procedures with connections and there are no activities on the level of doing mathematics. Both activities in the learning area of data processing are on the level of procedures without connections.

Table 2. *Cognitive demand levels of activities in Textbook B based on their learning areas*

	Number of gains	Memorization	Procedures without connections	Procedures with connections	Doing mathematics	Total
Numbers and operations	17	1	2	3	2	8
Probability	5	0	0	0	0	0
Geometry	17	0	14	4	6	24
Algebra	13	0	5	3	2	10
Data processing	2	0	1	0	0	1

When Table 2 is examined, it can be seen that the number of activities in Textbook B in all the learning areas except geometry is less than the number of gains. In the learning area of geometry, the number of activities provided is more than the number of gains. There is a total of 8 activities in the textbook in the learning area of numbers and operations, 1 of which is on the level of memorization, 2 are on the level of procedures without connections, 3 are on the level of procedures with connections and 2 are on the level of doing mathematics. No activities in the learning area of probability are included. Of a total of 24 activities in the learning area of geometry, 14 are on the level of procedures without connections, 4 are on the level of procedures with connections and 6 are on the level of doing mathematics and there are no activities on the level of memorization. In the learning area of algebra, there are a total of 10 activities, 5 of which are on the level of procedures without connections, 3 are on the level of procedures with connections, 2 are on the level of doing mathematics and there are no activities on the level of memorization. There is 1 activity in the learning area of data processing and it is on the level of memorization.

The cognitive demand levels of the activities in each of the examined textbooks based on learning areas are provided in Figure 9.

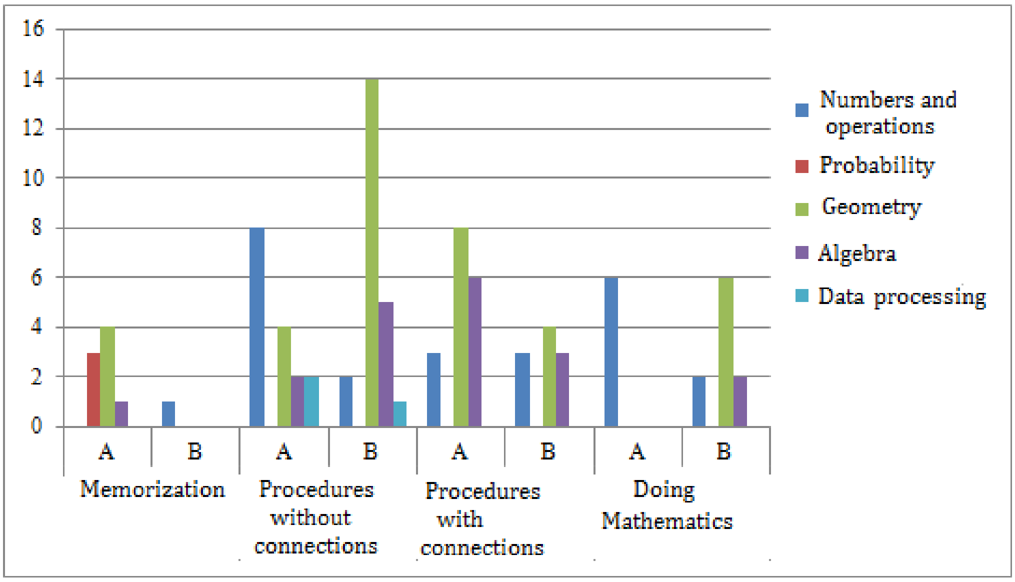


FIGURE 9. *Cognitive demand levels of activities in each of the examined textbooks based on their learning areas*

When Figure 9 is examined, it can be seen that while activities on the level of memorization are provided in three learning areas in Textbook A, such activities are only provided in one learning area in Textbook B. At the level of procedures without connections, the learning area of numbers and operations are dominant in Textbook A, while the learning area of geometry is dominant in Textbook B. At the level of procedures without connections, it can be seen that more activities in each learning area are provided in Textbook A compared to Textbook B. At the level of doing mathematics, it can be seen that only activities in the learning area of numbers and operations are provided in Textbook A, while activities in the learning areas of numbers and operations, geometry and algebra are provided in Textbook B.

DISCUSSION and CONCLUSION

In this study, the cognitive demand levels of the activities included in two 8th grade mathematics textbooks that are approved for teaching by the Board of Education of the Ministry of National Education were examined. When the distribution of activities based on their cognitive demand levels was examined it was seen that the number of low-level and high-level activities in both textbooks approximated each other (24 low-level and 23 high-level ones in Textbook A; 23 low-level and 20 high-level ones in Textbook B). The distribution of the activities examined by Ubuz, Erbaş, Çetinkaya and Özgeldi (2010) in terms of low-level and high-level cognitive demands was also observed to be similar. All students need to encounter activities at different levels. In fact, this balance of requirements may differ for students with a high level of academic success and students with a low level of academic success (Vincent & Stacey, 2008). When the cognitive demand levels of the activities in the textbooks of various countries and the mathematical achievements in international exams such as TIMSS and PISA are examined, it has been found that students experiencing activities with a high level of cognitive demand are more successful in these exams (Reçber, 2012). Due to the fact that if students are expected to think mathematically, develop their reasoning skills and have problem-solving abilities they must encounter high-level activities (Stein & Lane, 1996).

According to the distribution of the activities in the textbooks based on their cognitive demand levels, it can be seen that the lowest number of activities is at the memorization level, while the highest number of activities is at the level of procedures without connections. In the study of Ubuz and Sarpkaya (2014) where they examined the cognitive demand levels related to the learning area of second grade algebra in primary education, activities on the level of procedures without connections had the highest number (58.7%) while activities on the level of memorization had the lowest number (3.3%) according to the distribution of activities in the learning area of algebra included in the 8th grade textbook based on their cognitive demand levels. In this respect, the findings of both studies are similar. In general, it can be said that there is a need for guiding textbook authors in order to increase the number of activities in procedures with connections and doing mathematics levels.

When the cognitive demand levels of the two textbooks are compared, it can be seen that the number of activities at the level of memorization in Textbook B is less than the number of activities in the memorization level in Textbook A. However, the number of activities at the level of doing mathematics in Textbook B is higher than the number of activities at the level of doing mathematics in Textbook A. Considering that it is important for students to encounter more activities with high levels of cognitive demand than low-level activities (Ubuz & Sarpkaya, 2014), it can be said that students who use Textbook B have a greater advantage over students who use Textbook A as the former will encounter less activities at the level of memorization and more activities at the level of doing mathematics.

According to the findings obtained as a result of the analysis of the cognitive demand levels of all activities in the textbooks based on their learning areas, all 3 activities in the learning area of probability are assessed as being at the level of memorization. All 3 activities in the learning area of data processing are assessed as being on the level of procedures without connections. In the 2011 exam of TIMSS (Trends in International Mathematics and Science Study), which is a four-year screening study to evaluate the knowledge and skills of 4th and 8th grade students in science and mathematics, it can be seen that 20% of the 8th grade mathematics questions are from the learning areas of data processing and probability. On the other hand, 25% of the mathematics questions in the 2012 exam of PISA (Program for International Student Assessment), which is a research carried out by the Organization of Economic Cooperation and Development (OECD) that evaluates the knowledge and skills acquired by 15-year old students, were from the learning areas of uncertainty and data processing. This shows the importance of this learning area. Furthermore, probability is a very important topic in terms of acquiring the skill of thinking based on probability - which is one of the most important purposes of mathematics - and the skill of creative thinking (Gürbüz, Çatlıoğlu, Birgin & Erdem, 2007). Given that the learning areas of data processing and probability are so important, it is clear that more gains from these learning areas should be included and hence, there should be more high-level activities in textbooks.

According to the findings obtained, as a result of the examination of the learning areas of activities in each textbook based on their cognitive demand levels, 6 (13%) of the 47 activities in Textbook A are at the level of doing mathematics. The 6 activities at the level of doing mathematics are in the learning area of numbers and operations. There are no activities at the level of doing mathematics in the learning areas of probability, geometry, algebra and data processing. In fact, there are no activities at the level of procedures with connections in the learning areas of data processing and probability. In other words, there are no activities in these two learning areas that require high-level cognitive demands. The fact that, within a total of 43 activities in Textbook B, there are no activities related to the learning area of probability and the fact that there is only 1 activity in the learning area of data processing, which is a low-level (the level of procedures without connections) activity are noteworthy. In our country, the learning area of probability is an area in which teachers have difficulty in teaching and students have difficulty in understanding (Çakmak & Durmuş, 2015; Gokkurt-Özdemir, 2017; Mennun, 2008; Sezgin-Memnun, Altun & Yılmaz, 2010). The use of activities would help students in this learning area. Activities are used to materialize abstract concepts and to make learning more meaningful (Majoka, Dad & Mahmood, 2010). The availability of the lowest number of activities at the level of memorization and the highest number of activities at the level of procedures without connections in the learning areas of algebra and geometry in Textbook B, are consistent with the findings in the study of Ubuz & Sarpkaya (2014). Actually, the use of mentally challenging activities provides students with important opportunities for meaningful learning (Stylianides & Ball, 2008). If students are required to develop capabilities such as problem solving and inference, they need to encounter activities requiring a high level of cognitive demand (Stein & Lane, 1996).

Even though the textbooks are approved by the Board of Education as textbooks that can be taught, when the activities are compared among themselves it can be seen that they differ according to their cognitive demand levels and according to the general findings obtained from the research. In this respect, students educated with different textbooks may have different learning outcomes. This may cause the students who go through the same educational processes to be at different cognitive levels for mathematical concepts. This reveals the importance of a more thorough examination of the textbooks.

In this study, the cognitive demand levels of 8th grade textbooks were examined. The research can be repeated for different grade levels, or for cognitive demand levels of activities in different grades for specific learning areas. In addition, this research was conducted to examine only the activities in the textbook. The same research can be repeated for the exercises, problems and questions in the textbook. Studies comparing the activities in the 8th grade textbook with the cognitive demand levels of the questions in high school entrance exams for 8th grade students can also be conducted. When mathematics achievements in international examinations such as TIMSS and PISA are considered, it is seen that students who encounter high levels of cognitive demand in textbooks are more successful (Reçber, 2012). In this respect, it is possible to give trainings to the mathematics textbook authors on why the levels of cognitive demand are important, and what features should be given for an activity to be a high-level activity. In addition, studies can be done to increase the awareness of teachers in this context. Finally, the standards for writing textbooks should be determined, and more rigorous supervisory mechanisms should be constructed.

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