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Research Article

Analysis of Mathematics Textbook Activities by Cognitive Levels and TIMSS Cognitive Domains

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Abstract: Textbook activities play a central role in determining the cognitive opportunities offered to students and in translating curriculum expectations into classroom practice. This study aimed to evaluate the activities in Grade 5 and Grade 6 mathematics textbooks in terms of cognitive demand levels and TIMSS cognitive domains. Cognitive demand was classified as Memorization and Procedures Without Connections at the low level, and Procedures With Connections and Doing Mathematics at the high level. TIMSS cognitive domains were categorized as Knowledge, Application, and Reasoning. Using document analysis, 257 activities, including 124 Grade 5 and 133 Grade 6 activities, were examined. The findings showed that high-level cognitive demand activities constituted 60.5% of Grade 5 activities and 88.7% of Grade 6 activities. Procedures With Connections was the most frequent category at both grade levels, accounting for 54.8% of Grade 5 activities and 78.9% of Grade 6 activities. Doing Mathematics activities were less frequent, representing 5.6% of Grade 5 activities and 9.8% of Grade 6 activities. In Grade 5, high-level demand was particularly prominent in Algebraic Thinking with Operations and Geometric Shapes, whereas Numbers and Quantities included a higher proportion of low-level activities. In Grade 6, high-level demand was dominant across all learning areas, and no activity was classified as Memorization. Regarding TIMSS cognitive domains, Reasoning was the most frequent domain in both Grade 5 (41.1%) and Grade 6 (85.0%). Overall, the findings indicate that the textbooks provide substantial opportunities for conceptual understanding and mathematical reasoning, although activities requiring open-ended and non-algorithmic mathematical inquiry remain comparatively limited.

Keywords: Mathematics Textbook, Cognitive Demand, TIMSS Cognitive Domains, Curriculum

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1. Introduction

What students learn in mathematics is shaped by the content taught and the types of tasks through which they engage with that content. Mathematical activities can improve the quality of mathematics education and expand students' thinking skills (Henningsen & Stein, 1997). These activities aim to develop mathematical thinking in problem situations, direct students' attention to particular mathematical ideas, and promote lasting learning (Chapman, 2013). Accordingly, the cognitive processes and goals activated during an activity directly influence the level and quality of students' learning (Pekkan & Esmer, 2020).

Successfully answering mathematical questions requires students to perform appropriate operations, use information effectively in problem-solving, and make logical inferences (Henningsen & Stein, 1997). Cognitive demand refers to the type and level of thinking required from students while engaging in an activity (Stein et al., 2000). Therefore, planning activities at appropriate cognitive levels is a fundamental component of the teaching process (Pekkan & Esmer, 2020). High-level activities provide opportunities to make sense of mathematical ideas, establish relationships among concepts, and develop conceptual understanding. In contrast, low-level and rote-based activities offer limited support for students' mathematical development (Henningsen & Stein, 1997). The cognitive domain encompasses the mental dimensions of learning, including understanding, applying, problem-solving, and reasoning (Anderson & Krathwohl, 2001; Ausubel, 1968; Bloom et al., 1956; Hoque, 2016). Thus, the quality of mathematics education depends substantially on whether activities engage students in thinking processes consistent with the intended cognitive levels and domains.

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Textbooks are among the fundamental tools that reflect a country's understanding of mathematics education (Harries et al., 1998). They provide a framework for instruction, translate the curriculum into classroom practice, and guide students toward learning goals (Akyüz, 2006; Erbaş et al., 2012; Nicol & Crespo, 2006; Sevimli & Kul, 2015; Ubuz et al., 2010). Textbooks also influence what, how, and when content is taught and provide a common reference point for teachers and students during instruction (Altun et al., 2004; Arslan & Özpınar, 2009; Demirel & Kıroğlu, 2006). Mathematics education seeks to develop students' mathematical knowledge and prepare individuals who can use that knowledge effectively, participate in mathematical thinking processes, communicate mathematical ideas, and solve problems (Olkun & Toluk, 2003). Accordingly, textbook activities should encourage students to explore and construct knowledge and should support higher-order cognitive skills such as understanding, problem-solving, and reasoning (Akyüz, 2006; Fan & Zhu, 2007). Evaluating textbook activities can therefore provide evidence regarding the extent to which curriculum objectives are reflected in instructional materials (Doyle, 1983). Examining the cognitive demand levels and cognitive domains of these activities is particularly important for determining the adequacy and quality of textbooks as instructional resources (Remillard, 2000).

Because textbook activities shape the cognitive opportunities available to students, their structure may also influence students' preparedness for the types of mathematical thinking emphasized in national and international assessments. International large-scale assessments such as TIMSS, PISA, and PIRLS provide comparative information about student achievement and are widely used to monitor education systems and inform educational policies. In PISA 2022, Türkiye's mathematics performance remained below the OECD average, ranking 39th among 81 participating countries and 32nd among OECD countries (Ministry of National Education [MoNE], 2024; OECD, 2023). Previous research suggests that differences in countries' performance in international assessments may be partly related to the degree of alignment among textbook activities, curriculum expectations, and the cognitive processes assessed in these studies (Fan et al., 2013; Mullis et al., 2016; Schmidt et al., 2001; Törnroos, 2005). The reorganization of curricula in some TIMSS-participating countries in accordance with TIMSS cognitive domains further demonstrates the importance of examining the alignment between textbook activities and this framework (Delil et al., 2020).

In Türkiye, curriculum reforms are reflected in the revision of textbooks, which constitute one of the principal instructional resources through which curriculum expectations are translated into classroom practice (Arslan & Özpınar, 2009). Following the implementation of the revised curriculum, Grade 5 and Grade 6 students began using newly developed mathematics textbooks. Examining the activities in these textbooks is important because they are newly introduced materials and because they shape the cognitive opportunities offered to students during mathematics learning. Textbook activities may support or restrict students' engagement in conceptual understanding, application, reasoning, problem-solving, and non-routine mathematical inquiry. Evaluating these activities through cognitive demand levels and TIMSS cognitive domains can therefore provide evidence regarding the extent to which the revised textbooks reflect the aims of the current curriculum and prepare students for the cognitive processes emphasized in international assessment frameworks.

Previous studies have examined mathematics textbooks and curricula from different cognitive perspectives in national and international contexts. In Türkiye, studies focusing on cognitive demand have shown that mathematics textbooks and curriculum objectives frequently include tasks that require conceptual connections. However, opportunities for non-routine mathematical inquiry and Doing Mathematics may remain limited or may be distributed unevenly across topics and grade levels (Engin & Sezer, 2016; Horzum & Duran, 2024; Namlı & Özçakır, 2024; Polat & Dede, 2022; Reçber & Sezer, 2018). Other studies conducted in Türkiye have analyzed textbook tasks, workbook questions, and curriculum outcomes according to TIMSS cognitive domains. Their findings indicate that instructional materials may not always provide a balanced distribution across knowledge, application, and reasoning (Delil et al., 2020; Güner, 2015; İncikabı et al., 2016; Sönmez, 2017; Sümen, 2021; Taşpınar Şener & Kılıç Bulut, 2022). International and comparative studies have similarly examined the cognitive structures of mathematics textbooks and curricula across education systems. These studies show that the distribution of textbook tasks across cognitive categories varies among countries and shapes students' opportunities to learn mathematics (Basyal et al., 2023; Cil, 2022; Lessani et al., 2014; Palacios & García, 2018; Yang & Sianturi, 2022).

More recent studies in Türkiye have examined the current mathematics curriculum and curriculum-related documents from perspectives such as Structure of the Observed Learning Outcome (SOLO) taxonomy, cognitive demand, and skills. However, these studies have primarily focused on curriculum documents or learning outcomes rather than the activities included in the newly developed Grade 5 and Grade 6 mathematics textbooks (Cihan & Doruk, 2024; Kıryak et al., 2024; Satmaz & Yabanova, 2024). Studies published in 2025 also indicate growing scholarly interest in the Türkiye Century Education Model and the newly developed mathematics textbooks. Güler et al. (2025) examined the mathematics and science curricula of the Türkiye Century Education Model according to the TIMSS 2027 cognitive domains. İnci Kuzu et al. (2025) analyzed the Grade 5 mathematics textbook prepared within the Türkiye Century Education Model in terms of mathematical connections, whereas Altan et al. (2025) examined the activities in Grade 5 mathematics textbooks according to the NCTM process standards. Kaplan (2025) compared algebra content in Turkish and U.S. middle school mathematics textbooks in terms of cognitive demand and mathematical critical thinking, and Uzun (2025) analyzed the cognitive demand levels of probability tasks in the 2024 Grade 9 mathematics textbook.

These recent studies demonstrate that the revised curriculum and newly developed mathematics textbooks have begun to be investigated through perspectives such as mathematical connections, process standards, cognitive demand, algebra content, probability tasks, and TIMSS-related classifications. Nevertheless, they do not directly examine the activities in the revised Grade 5 and Grade 6 mathematics textbooks through the combined lens of cognitive demand levels and TIMSS cognitive domains. A review of the relevant literature indicates that no previous study has simultaneously analyzed the activities in these textbooks according to both frameworks. This gap creates a need to evaluate the cognitive quality of the newly implemented textbooks, examine their alignment with curriculum expectations and international assessment frameworks, and provide evidence that may inform textbook development, classroom practice, and future curriculum revisions.

Accordingly, this study aims to examine the activities included in the Grade 5 and Grade 6 middle school mathematics textbooks prepared in line with the revised curriculum in terms of cognitive demand levels and TIMSS cognitive domains. The main research question is as follows:

What is the distribution of the activities in the Grade 5 and Grade 6 mathematics textbooks prepared according to the revised curriculum in terms of cognitive demand levels and TIMSS cognitive domains?

By doing so, the study endeavors to provide data-based contributions to textbook development and the shaping of educational policies. The study may also contribute to understanding why students' achievement levels in international assessments fall below expectations and establish a basis for future international comparative studies. By addressing an area that has not been examined through the combined use of cognitive demand levels and TIMSS cognitive domains, the study aims to strengthen the literature on the revised mathematics textbooks. Its findings may guide decision-makers, textbook authors, researchers, and educators.

2. Theoretical Background and Analytical Framework

Activity is a broad concept referring to structured interactions, practices, and tasks that support the teaching-learning process. Within educational contexts, the terms learning activity and teaching activity emphasize different aspects of this broader concept. Learning activities focus on the experiences and actions through which students construct knowledge, whereas teaching activities refer to the practices organized by teachers to support and guide learning. Despite this difference in emphasis, both involve teacher-student interactions and classroom practices intended to facilitate learning (Doyle, 1983; MacDonald, 2008; Stein & Lane, 1996).

Within mathematics education, the broader concept of activity becomes more specific through the terms mathematical activity and mathematical task. These terms refer to structured opportunities that engage students in mathematical content, processes, and ways of thinking. In this study, mathematical activity and mathematical task are used in a closely related sense to describe the mathematical work presented to students through textbook activities. Such activities aim to develop students' mathematical thinking and deepen their understanding of mathematical ideas (Chapman, 2013; Henningsen & Stein, 1997). Bozkurt (2012) describes activities as tasks in which students assume responsibility and use relevant tools to complete the expected mathematical work.

An effective mathematical activity integrates mathematical content, pedagogical approaches, and targeted competencies within a coherent structure. Activities based primarily on procedural routines may restrict students' opportunities to think, whereas conceptually oriented activities can expand these opportunities (Stein & Smith, 1998). Mathematical activities therefore shape students' opportunities to reason, establish connections, and construct mathematical meaning. Their design should reflect the mathematical content to be learned and the cognitive processes expected from students (Chapman, 2013; Henningsen & Stein, 1997; Stein & Smith, 1998).

The constructivist approach provides a theoretical basis for this understanding of mathematical activity. From a constructivist perspective, learning involves the active construction of meaning through prior knowledge, experience, and cognitive engagement (Ausubel, 1968; Piaget, 1970; von Glasersfeld, 1995). Cognitive appropriateness is therefore a central characteristic of an effective mathematical activity. Activities should encourage students to process information, establish relationships, interpret mathematical ideas, and engage in higher-order thinking processes (Anderson & Krathwohl, 2001; Stein et al., 2000). In educational contexts, cognition encompasses the processes of acquiring, processing, and using knowledge (Akpunar, 2011). Mathematical activities activate these processes by requiring students to engage with mathematical ideas at different levels and through different forms of thinking.

Accordingly, mathematical activities can be examined according to both the depth of thinking they require and the type of cognitive process they emphasize. In the present study, textbook activities are therefore evaluated through two complementary analytical lenses: cognitive demand levels and TIMSS cognitive domains. Cognitive demand levels indicate the complexity and depth of the mathematical thinking required by an activity, whereas TIMSS cognitive domains identify whether the activity primarily emphasizes knowledge, application, or reasoning. Together, these frameworks provide a basis for examining the cognitive characteristics of the mathematical activities included in the textbooks.

Activities in mathematics education can be classified through different cognitive approaches. Doyle (1983) classified instructional tasks as memorization, routine procedures, understanding, and thinking-based tasks, drawing attention to the type of intellectual work required from students. Bloom's Taxonomy and its revised version provide a broader framework for describing cognitive processes such as remembering, understanding, applying, analyzing, evaluating, and creating (Anderson & Krathwohl, 2001; Bloom et al., 1956). TIMSS cognitive domains classify mathematical tasks according to the nature of the cognitive process required for solving them, namely knowledge, application, and reasoning (Mullis & Martin, 2017; Mullis et al., 2020). These approaches provide useful perspectives for describing students' cognitive engagement in learning and assessment contexts. In the present study, the cognitive demand framework developed by Stein et al. (2000) was selected because it was designed specifically for analyzing mathematical tasks and the level of thinking required by these tasks. This framework distinguishes between low-level and high-level cognitive demand and provides clear categories for identifying whether an activity requires recall, routine procedures, conceptual connections, or complex mathematical inquiry. The framework is appropriate for this study because the unit of analysis is the textbook activity. It enables the analysis to focus on the depth of mathematical thinking expected from students as they engage with each activity. Therefore, the Stein et al. (2000) framework was used to evaluate the cognitive demand levels of textbook activities, and the TIMSS cognitive domains framework was used as a complementary lens to identify the type of cognitive process emphasized in each activity. Accordingly, cognitive demands are examined under two main categories: Low-Level Cognitive Demand and High-Level Cognitive Demand. Low-level demands are divided into two categories: "Memorization" and "Procedures Without Connections." High-level demands are divided into two categories: "Procedures With Connections" and "Doing Mathematics."

In activities at the Memorization level, students generally answer rote-based questions related to mathematical definitions and rules, and such tasks do not require higher-order thinking skills. In activities at the level of Procedures Without Connections, students perform mathematical operations based solely on the rules they remember, without establishing conceptual connections. At the level of Procedures With Connections, students are expected to deeply understand mathematical concepts by relating them to real-life situations or other mathematical areas. In activities at the Doing Mathematics level, students encounter unstructured problems that require open-ended and multifaceted thinking; in this process, they develop different solution paths and use advanced mathematical thinking skills (Stein et al., 2000).

The cognitive demand framework provides the first dimension of the analysis by identifying the depth and complexity of mathematical thinking required by each textbook activity. This framework is useful for determining whether an activity requires recall, routine procedure, conceptual connection, or non-algorithmic mathematical inquiry. However, cognitive demand level alone does not fully describe the specific type of cognitive process emphasized in an activity. For instance, two activities may both be classified as high-level cognitive demand, yet one may mainly require students to apply mathematical knowledge in a familiar context, whereas the other may require students to justify, infer, or generalize. Therefore, a second analytical framework was needed to identify the dominant cognitive process required by each activity. For this purpose, the TIMSS cognitive domains framework was included in the analysis. TIMSS was selected because it provides an internationally recognized framework for classifying mathematical tasks according to the cognitive processes emphasized in large-scale mathematics assessments. Since one aim of this study is to evaluate the cognitive opportunities offered by revised mathematics textbooks in relation to international assessment expectations, the TIMSS framework provides a relevant basis for examining whether textbook activities emphasize knowledge, application, or reasoning (Mullis & Martin, 2017; Mullis et al., 2020). In this way, TIMSS cognitive domains extend the analysis from the level of cognitive demand to the orientation of cognitive processing.

The TIMSS cognitive domain classification was developed with reference to Bloom's Taxonomy and has been organized around three main dimensions since the 2007 assessment cycle: knowledge, application, and reasoning (Mullis & Martin, 2017). TIMSS evaluates students' mathematical knowledge and their ability to use, interpret, and reason with this knowledge in different problem situations (Mullis et al., 2020). Unlike Bloom's Taxonomy, TIMSS cognitive domains do not follow a hierarchical structure; they classify tasks according to the primary cognitive process required for solving them (Delil et al., 2020). The knowledge domain refers to recalling, recognizing, and using basic mathematical information such as definitions, concepts, operations, numbers, symbols, and spatial relationships. The application domain refers to using learned knowledge in routine or familiar problem situations, interpreting mathematical representations such as graphs, tables, and figures, and selecting appropriate solution strategies. The reasoning domain refers to logical and multi-step thinking processes such as analyzing, inferring, generalizing, justifying, and validating mathematical ideas in complex or unfamiliar situations (Mullis & Martin, 2017; Mullis et al., 2020).

The relationship between the two frameworks is central to the analytical structure of this study. The cognitive demand framework identifies the cognitive depth of an activity, and the TIMSS cognitive domains framework identifies the cognitive process orientation of the same activity. For example, an activity may be coded as Procedures With Connections because it requires students to connect a procedure with an underlying mathematical concept. The same activity may be coded in the TIMSS application domain if it asks students to use that conceptual connection in a familiar problem situation. Another activity may also be coded as Procedures With Connections, but it may fall within the TIMSS reasoning domain if it requires students to explain a relationship, justify a conclusion, or make a generalization. Therefore, the two frameworks do not duplicate each other; they generate different but related information about the same textbook activity. In this study, each textbook activity was coded according to one cognitive demand level and one TIMSS cognitive domain. This coding structure enabled the analysis to capture both the cognitive depth and the cognitive process orientation of the activities. The cognitive demand framework showed the quality and complexity of the mathematical work expected from students. The TIMSS cognitive domains framework showed whether this work primarily involved knowledge, application, or reasoning. The combined use of these frameworks therefore provided a more comprehensive account of the learning opportunities offered by the revised Grade 5 and Grade 6 mathematics textbooks. Together, the cognitive demand framework (Stein et al., 2000) and TIMSS cognitive domains (Mullis & Martin, 2017) provide a coherent basis for describing both the depth and the nature of thinking opportunities offered by textbook activities.

3. Method

3.1. Research design

In this study, a qualitative research approach was adopted to examine and interpret the cognitive characteristics of textbook activities as written instructional materials. Qualitative research is appropriate for studies that aim to analyze meanings, structures, and patterns within educational

materials in relation to a specific research purpose (Creswell, 2009). Accordingly, the study was designed as a document analysis, focusing on the systematic examination of Grade 5 and Grade 6 mathematics textbooks. Document analysis involves the planned and systematic review, interpretation, and evaluation of documents as data sources in qualitative research (Bowen, 2009). Textbooks are official curriculum-related documents that reflect instructional content, learning opportunities, and pedagogical expectations. Therefore, document analysis provides an appropriate methodological basis for examining the cognitive characteristics of textbook activities (Bowen, 2009; Forster, 1995).

The study-specific procedures implemented at each stage of the five-step document analysis are presented below. Following Forster's (1995) five-stage document analysis process, the procedures implemented in this study were as follows: (1) Accessing the relevant documents: The Grade 5 and Grade 6 mathematics textbooks used in Türkiye were identified, and Book 1 and Book 2 for each grade level were obtained online as the primary data sources (MoNE, 2025a, 2025b, 2025c, 2025d). (2) Evaluating document authenticity: To ensure that the materials were appropriate and trustworthy for analysis, publication information (e.g., title, grade level, and edition/version details) was checked, and the final versions used in the study were archived to establish an audit trail. (3) Understanding and interpreting the contents: Prior to coding, both textbook sets were read multiple times to (a) identify the unit of analysis as an "activity" (i.e., tasks explicitly presented to engage students in mathematical work), (b) map each activity to the relevant learning area in the textbooks, and (c) develop a shared coding protocol using the indicators presented in Table 2. This stage supported a common interpretation of the analytical framework and consistent implementation across coders. (4) Systematically analyzing the data: Using the established protocol, all activities (n = 257) were coded descriptively according to one cognitive demand level (Stein et al., 2000) and one TIMSS cognitive domain (Mullis et al., 2020). The researchers first coded the activities independently and then compared their codes; disagreements were discussed and resolved through consensus to strengthen the dependability of the coding process. (5) Using the analysis results within the scope of the research: Finally, the coded dataset was aggregated to produce frequency distributions by learning area and category, and illustrative examples (see Appendix A) were reported to enhance transparency and enable readers to follow how the classifications were applied.

3.2. Data collection and analysis

The data for this study consisted of mathematical activities collected from the official Grade 5 and Grade 6 mathematics textbooks used in Türkiye (MoNE, 2025a, 2025b, 2025c, 2025d). In this study, the unit of analysis was defined as the sections explicitly presented as "activities" in the textbooks. Therefore, all textbook sections labelled as activities were included in the dataset. Information boxes, explanatory texts, worked examples, measurement and evaluation questions, additional problems, and end-of-unit assessment items were excluded from the analysis. This scope was determined to focus specifically on the cognitive opportunities provided through the activity sections of the textbooks. A total of four textbooks were examined, including Book 1 and Book 2 for each grade level. A total of 257 activities were analyzed, including 124 activities from the Grade 5 textbooks and 133 activities from the Grade 6 textbooks. The distribution of these activities according to grade level and learning area is presented in Table 1.

Table 1

Distribution of the Analyzed Activities by Grade Level and Learning Area

Learning area	Grade 5	Grade 6	Total
Numbers and Quantities	26	45	71
Algebraic Thinking with Operations	25	17	42
Geometric Shapes	37	14	51
Geometric Quantities	8	15	23
Statistical Research Process	20	38	58
From Data to Probability	8	4	12
Total	124	133	257

The textbook activities were analyzed through descriptive analysis within a document analysis design. The analysis was based on predefined categories derived from the cognitive demand framework (Stein et al., 2000) and the TIMSS cognitive domains framework (Mullis et al., 2020).

Table 2

Analytical Framework

Theme			Indicators
Cognitive Demand Levels	Low-Level Demand	Memorization	Recall of learned information, rules, formulas, definitions
			No method or insufficient time
			No uncertainty
		Procedures Without Connections	Reviewing previously learned material
			Algorithmic, method clearly stated
			Limited cognitive demand
			No conceptual connections
			Focus on correct answers, minimal explanation
	High-Level Demand	Procedures With Connections	Application of general methods related to underlying concepts
			Multiple representations
			Connecting representations
		Doing Mathematics	Requires thinking process
			Complex, non-algorithmic thinking
			Exploration of concepts and relationships
			Self-regulation of cognitive processes
			Analysis of solutions and strategies
			High cognitive effort
TIMSS Cognitive Domains	Knowledge		Remembering and recognizing basic math knowledge
			Performing calculations
			Classifying numbers, shapes, quantities
			Interpreting graphs or tables
	Application		Applying knowledge to different problems
			Using multiple info elements
			Creating equations, tables, graphs
			Routine problem situations
	Reasoning		Logical, multi-step thinking
			Reasoning, inference
			Finding general relationships
			Proof and alternative approaches

For the evaluation of the cognitive demand levels of the activities, the Task Analysis Guide developed by Stein et al. (2000) was used. For the evaluation of the activities according to cognitive domains, the TIMSS cognitive domains framework (Mullis et al., 2020) was adopted, which classifies tasks into Knowledge, Application, and Reasoning according to the cognitive processes required for problem solving. Based on the coding indicators presented in Table 2, each activity was coded according to one cognitive demand category and one TIMSS cognitive domain, and the resulting data were analyzed descriptively. Table 2 served as the analytical codebook for the coding process by defining the indicators used to classify activities across both frameworks.

To further clarify how the coding categories were applied, illustrative examples from the analyzed textbook activities are provided in Appendix A. These examples demonstrate how activities were classified as Memorization, Procedures Without Connections, Procedures with Connections, Doing Mathematics, Knowledge, Application, and Reasoning. For example, an activity requiring students to convert decimal representations into fractions and order them was coded as Memorization, as it mainly required recalling and reproducing previously learned knowledge. An activity requiring

students to explore angle relationships by placing acetate sheets in different positions was coded as Doing Mathematics, as it required exploration, strategy development, and justification. During the coding process, disagreements between coders were discussed with reference to the indicators in Table 2 and the illustrative examples in Appendix A until consensus was reached.

3.3. Validity and reliability

To ensure the trustworthiness of this study, strategies such as thick description (Creswell, 2009) and peer review (Lincoln & Guba, 1985) were employed. Thick description was supported by clearly defining the unit of analysis, explaining the coding indicators, and providing illustrative examples of coding decisions. In this context, Table 2 presents the analytical codebook used in the coding process, and Appendix A provides examples of how textbook activities were coded according to cognitive demand levels and TIMSS cognitive domains. The coding process was carried out in two stages. In the first stage, the researchers independently coded the activities using the indicators presented in Table 2. In the second stage, the independently coded data were compared, and discrepancies were discussed until consensus was reached. During this process, the researchers referred to both the analytical indicators in Table 2 and the illustrative examples in Appendix A. This procedure was used to strengthen the consistency, transparency, and dependability of the coding process. To enhance internal validity, all activities were examined systematically in relation to the predefined analytical categories. To improve external validity, the theoretical foundations, coding indicators, and document analysis procedures were clearly described. These procedures contributed to the methodological rigor of the study and reinforced confidence in its findings (Creswell, 2009; Lincoln & Guba, 1985).

4. Findings

First, the activities were evaluated according to cognitive demand levels for the Grade 5 textbook, followed by the Grade 6 textbook. Then, the activities were evaluated according to the TIMSS cognitive domains for the Grade 5 textbook and the Grade 6 textbook (Tables 3–6).

Table 3

Cognitive Demand Levels of Activities in the Grade 5 Mathematics Textbooks

Learning Area	***Low-Level Demand***		***High-Level Demand***		***Total Activities***
	Memorization	***Procedures Without Connections***	***Procedures With Connections***	***Doing Mathematics***	
Overall	14	35	68	7	124
Geometric Shapes	1	10	24	2	37
Numbers and Quantities	8	12	6	0	26
Geometric Quantities	0	3	5	0	8
Statistical Research Process	3	6	10	1	20
Algebraic Thinking with Operations	1	2	18	4	25
From Data to Probability	1	2	5	0	8

Table 3 presents the distribution of activities in the Grade 5 mathematics textbooks by cognitive demand levels. Overall, 75 of the 124 Grade 5 activities (60.5%) were coded as high-level demand, whereas 49 activities (39.5%) were coded as low-level demand. The most frequent category was Procedures With Connections (n = 68; 54.8%), followed by Procedures Without Connections (n = 35; 28.2%), Memorization (n = 14; 11.3%), and Doing Mathematics (n = 7; 5.6%). These findings indicate that more than half of the Grade 5 textbook activities require students to make conceptual connections, whereas nearly two-fifths primarily emphasize recall and routine procedures.

When learning areas are considered separately, marked differences are observed in the Grade 5 mathematics textbooks. In the Geometric Shapes learning area, 26 of 37 activities (70.3%) were coded as high-level demand (Procedures With Connections: n = 24; Doing Mathematics: n = 2), indicating that the analyzed activities in this learning area were predominantly structured around conceptual connections. In contrast, in the Numbers and Quantities learning area, 20 of 26 activities (76.9%) were coded as low-level demand (Memorization: n = 8; Procedures Without Connections: n = 12),

and no activity was coded as Doing Mathematics. These findings indicate that, within the analyzed Grade 5 textbook activities, the Numbers and Quantities learning area was represented mainly through procedural and recall-oriented tasks, whereas activities requiring open-ended mathematical exploration were not observed. In Geometric Quantities, 5 of 8 activities (62.5%) were coded as Procedures With Connections and none as Memorization or Doing Mathematics, suggesting an emphasis on conceptual linking but limited opportunities for open-ended mathematical production. In the Statistical Research Process, 11 of 20 activities (55.0%) were coded as high-level demand, and one activity was coded as Doing Mathematics, indicating that higher-level engagement was present but limited in this learning area. The strongest emphasis on high-level demand appeared in Algebraic Thinking with Operations, where 22 of 25 activities (88.0%) were coded as high-level demand (Procedures With Connections: n = 18; Doing Mathematics: n = 4). Finally, in From Data to Probability, 5 of 8 activities (62.5%) were coded as Procedures With Connections and none as Doing Mathematics. Overall, the Grade 5 textbook activities showed stronger high-level cognitive demand in Algebraic Thinking with Operations and Geometric Shapes, while the Numbers and Quantities activities were more frequently coded at low-level demand. The scarcity of Doing Mathematics tasks (n = 7; 5.6% overall) indicates limited systematic opportunities for students to engage in complex, non-algorithmic exploration and self-regulated mathematical production.

A total of 133 activities in the Grade 6 mathematics textbooks were examined according to cognitive demand levels. Table 4 presents the findings of the descriptive analysis regarding the cognitive demand levels of the activities.

Table 4

Cognitive Demand Levels of Activities in the Grade 6 Mathematics Textbooks

Learning Area	***Low-Level Demand***		***High-Level Demand***		***Total Activities***
	Memorization	***Procedures Without Connections***	***Procedures With Connections***	***Doing Mathematics***	
Overall	0	15	105	13	133
Geometric Shapes	0	2	8	4	14
Numbers and Quantities	0	7	38	0	45
Geometric Quantities	0	1	7	7	15
Statistical Research Process	0	3	35	0	38
Algebraic Thinking with Operations	0	2	15	0	17
From Data to Probability	0	0	2	2	4

Table 4 presents the distribution of activities in the Grade 6 mathematics textbooks by cognitive demand levels. Overall, 118 of 133 activities (88.7%) were coded as high-level demand, whereas 15 activities (11.3%) were coded as low-level demand. The most frequent category was Procedures With Connections (n = 105; 78.9%), followed by Procedures Without Connections (n = 15; 11.3%) and Doing Mathematics (n = 13; 9.8%), while no activity was coded as Memorization. Directly stated, the Grade 6 textbook is overwhelmingly oriented toward conceptually connected and cognitively demanding activities, with no recall-based activities identified.

When learning areas are considered separately, high-level demand is dominant across all areas. In Geometric Shapes, 12 of 14 activities (85.7%) were coded as high-level demand (Procedures with Connections: n = 8; Doing Mathematics: n = 4), indicating that this learning area includes not only conceptual linking but also a notable amount of complex, non-routine mathematical work. In Numbers and Quantities, 38 of 45 activities (84.4%) were coded as Procedures with Connections, while 7 activities (15.6%) were coded as Procedures Without Connections and none as Doing Mathematics. This directly shows that the strand strongly emphasizes conceptual relationships, although opportunities for open-ended mathematical production remain limited. In Geometric Quantities, 14 of 15 activities (93.3%) were high-level demand, and the distribution between Procedures with Connections (n = 7) and Doing Mathematics (n = 7) was balanced. This suggests that geometric quantities provides particularly strong opportunities for students to engage in both conceptual connections and non-algorithmic exploration. In the Statistical Research Process, 35 of 38 activities (92.1%) were coded

as Procedures with Connections, with only 3 activities (7.9%) at the Procedures Without Connections level, indicating a highly demanding structure centered on interpretation and reasoning. Similarly, in Algebraic Thinking with Operations, 15 of 17 activities (88.2%) were coded as Procedures with Connections, with only 2 activities (11.8%) classified as Procedures Without Connections. Finally, in From Data to Probability, all 4 activities (100%) were coded as high-level demand, with an equal distribution between Procedures with Connections (n = 2) and Doing Mathematics (n = 2). In direct terms, the Grade 6 mathematics textbooks demonstrate a very strong overall orientation toward high-level cognitive demand across all learning areas. However, the distribution of Doing Mathematics remains uneven, being concentrated mainly in geometric quantities, geometric shapes, and From Data to Probability.

Taken together, the findings from Tables 3 and 4 show that both textbooks include a substantial number of high-level demand activities, but the Grade 6 textbook demonstrates a much stronger and more consistent emphasis on cognitively demanding tasks. While the Grade 5 textbook presents a mixed profile, with high-level demand concentrated particularly in algebraic thinking and lower-level demand still prominent in numbers and quantities, the Grade 6 textbook is characterized by the near-total absence of memorization tasks and a dominant focus on Procedures with Connections across all learning areas. This pattern suggests a developmental shift from a more uneven cognitive structure in Grade 5 toward a more uniformly high-demand structure in Grade 6. However, in both textbooks, opportunities for students to engage in Doing Mathematics remain comparatively limited and unevenly distributed across learning areas.

The 124 activities in the Grade 5 mathematics textbooks were also evaluated according to the TIMSS cognitive domains. Table 5 presents the distribution of activities according to the TIMSS cognitive domains.

Table 5

TIMSS Cognitive Domains of Activities in the Grade 5 Mathematics Textbooks

Learning Area	***Knowledge***	***Application***	***Reasoning***	***Total Activities***
Overall	29	44	51	124
Geometric Shapes	14	14	9	37
Numbers and Quantities	6	9	11	26
Geometric Quantities	1	6	1	8
Statistical Research Process	3	5	12	20
Algebraic Thinking with Operations	3	8	14	25
From Data to Probability	2	2	4	8

Table 5 presents the distribution of activities in the Grade 5 mathematics textbooks according to TIMSS cognitive domains. Overall, Reasoning was the most frequent domain among the 124 Grade 5 activities (n = 51; 41.1%), followed by Application (n = 44; 35.5%) and Knowledge (n = 29; 23.4%). Directly stated, the textbook places the greatest emphasis on reasoning-oriented tasks, with application also strongly represented, while knowledge-level tasks form the smallest share.

Across learning areas, the domain emphasis varies. In Geometric Shapes, Knowledge (n = 14) and Application (n = 14) were equally frequent (each 37.8%), while Reasoning was lower (n = 9; 24.3%). This directly indicates that geometric shapes activities prioritize recognizing and applying concepts more than engaging in extended reasoning. In Numbers and Quantities, Reasoning (n = 11; 42.3%) was the dominant domain, followed by Application (n = 9; 34.6%) and Knowledge (n = 6; 23.1%). Geometric Quantities was strongly dominated by Application (n = 6; 75.0%), with minimal Knowledge and Reasoning (each n = 1; 12.5%), showing a clear focus on using procedures and applying rules in routine contexts. In the Statistical Research Process, Reasoning was clearly dominant (n = 12; 60.0%), indicating substantial emphasis on interpreting data, drawing conclusions, and justifying results. Similarly, in Algebraic Thinking with Operations, Reasoning constituted the majority (n = 14; 56.0%), followed by Application (n = 8; 32.0%) and Knowledge (n = 3; 12.0%). In From Data to Probability, Reasoning accounted for half of the activities (n = 4; 50.0%), while Knowledge and Application were equally represented (each n = 2; 25.0%). In direct terms, reasoning is particularly prominent in statistics and algebraic thinking, whereas geometric quantities is primarily application-oriented and

geometric shapes is comparatively less reasoning-intensive. The distribution across TIMSS domains shows that the textbook generally supports higher-order cognitive processing through reasoning tasks; however, the imbalance across learning areas suggests that opportunities for reasoning are not evenly embedded throughout the curriculum, especially in geometry-related strands where knowledge and application dominate.

The 133 activities in the Grade 6 mathematics textbooks were also evaluated according to the TIMSS cognitive domains. Table 6 presents the distribution of activities according to the TIMSS cognitive domains.

Table 6

TIMSS Cognitive Domains of Activities in the Grade 6 Mathematics Textbooks

Learning Area	*Knowledge*	*Application*	*Reasoning*	*Total Activities*
Overall	0	20	113	133
Geometric Shapes	0	3	11	14
Numbers and Quantities	0	10	35	45
Geometric Quantities	0	1	14	15
Statistical Research Process	0	3	35	38
Algebraic Thinking with Operations	0	2	15	17
From Data to Probability	0	1	3	4

Table 6 presents the distribution of activities in the Grade 6 mathematics textbooks according to TIMSS cognitive domains. Overall, Reasoning was by far the most frequent domain among the 133 Grade 6 activities (n = 113; 85.0%), followed by Application (n = 20; 15.0%), while no activity was coded in the Knowledge domain. Directly stated, the Grade 6 textbook places an exceptionally strong emphasis on reasoning-oriented tasks and provides very limited emphasis on routine knowledge-level performance.

Across learning areas, Reasoning is dominant in all strands. In Geometric Shapes, 11 of 14 activities (78.6%) were coded as reasoning, while 3 activities (21.4%) were coded as application. This indicates that geometric shapes activities are largely structured around making inferences and justifying geometric relationships rather than simply applying known rules. In Numbers and Quantities, 35 of 45 activities (77.8%) were classified as reasoning and 10 activities (22.2%) as application, suggesting that this learning area goes substantially beyond procedural use and instead emphasizes explanation and generalization. In Geometric Quantities, 14 of 15 activities (93.3%) were coded as reasoning, with only 1 activity (6.7%) in application. This directly shows that geometric quantities is one of the most reasoning-intensive strands in the textbook. Similarly, in the Statistical Research Process, 35 of 38 activities (92.1%) were coded as reasoning, indicating a strong focus on interpreting information, drawing conclusions, and making justified decisions from data. In Algebraic Thinking with Operations, 15 of 17 activities (88.2%) were reasoning-oriented, while 2 activities (11.8%) were application-based, showing that algebraic work is also heavily centered on higher-order thinking. Finally, in From Data to Probability, 3 of 4 activities (75.0%) were coded as reasoning and 1 activity (25.0%) as application. In direct terms, the Grade 6 textbook shows a highly consistent cognitive profile in favor of reasoning across all learning areas. Compared with a more balanced distribution across domains, this pattern suggests a textbook design that systematically prioritizes inference, explanation, and multi-step thinking over factual recall or straightforward execution.

Taken together, the findings from Tables 5 and 6 indicate that both textbooks tend to support higher-order thinking through application and especially reasoning, but this tendency is much more pronounced in the Grade 6 textbook. Whereas the Grade 5 textbook shows a more balanced distribution across knowledge, application, and reasoning, the Grade 6 textbook is overwhelmingly dominated by reasoning and contains no activities coded in the knowledge domain. This comparison suggests that the cognitive orientation of the textbook set becomes increasingly reasoning-centered from Grade 5 to Grade 6. At the same time, the uneven distribution of domains across learning areas in the Grade 5 textbook and the very limited role of application in the Grade 6 textbook indicate that cognitive opportunities are not distributed in exactly the same way across grades and content strands.

5. Conclusion and Discussion

5.1. Overall cognitive profile of the textbooks

In this study, 124 activities in the Grade 5 mathematics textbooks and 133 activities in the Grade 6 mathematics textbooks were examined through descriptive analysis in terms of cognitive demand levels and TIMSS cognitive domains. The findings indicate that the cognitive profile of the analyzed textbook activities differs across grade levels. Within the analyzed textbook set, the Grade 6 textbooks showed a stronger emphasis on high-level cognitive demand and TIMSS reasoning than the Grade 5 textbooks. This comparison refers specifically to the Grade 5 and Grade 6 textbooks analyzed in the present study; it does not imply a direct comparison with previous textbooks or previous curricula.

In the Grade 5 textbooks, the majority of activities were coded as high-level demand, yet the distribution across learning areas was uneven. Algebraic Thinking with Operations and Geometric Shapes included relatively stronger opportunities for higher-level cognitive engagement, while the Numbers and Quantities learning area included a higher proportion of low-level demand activities. The predominance of Procedures With Connections indicates that many Grade 5 activities were designed to support conceptual relationships and mathematical meaning-making. The limited number of Doing Mathematics activities shows that opportunities for non-routine problem solving, self-regulated inquiry, and original mathematical production were comparatively restricted.

In the Grade 6 textbooks, the cognitive profile was more consistently oriented toward high-level demand. High-level demand activities were dominant across all learning areas, and no activity was coded as Memorization. Procedures With Connections constituted the largest category, and TIMSS reasoning was the most frequent cognitive domain. These findings suggest that the Grade 6 textbooks in the analyzed set place stronger emphasis on conceptual relationships, interpretation, explanation, and mathematical justification than the Grade 5 textbooks. At the same time, Doing Mathematics activities remained limited in number and were concentrated in particular learning areas, especially Geometric Quantities, Geometric Shapes, and From Data to Probability.

5.2. Cognitive demand levels across grades and learning areas

The first major finding concerns the distribution of cognitive demand levels across grade levels and learning areas. The proportion of high-level demand activities increased from 60.5% in the Grade 5 textbooks to 88.7% in the Grade 6 textbooks. This increase should be interpreted as a grade-level difference within the analyzed textbook set. It does not provide evidence of change over time in comparison with previous textbook editions. The stronger presence of high-level demand in the Grade 6 textbooks is important because cognitively demanding mathematical tasks create opportunities for students to reason, establish connections, and engage with mathematical ideas at a deeper level (Henningsen & Stein, 1997; Stein et al., 2000). Tasks with higher cognitive demand have also been associated with students' opportunities to develop conceptual understanding, creative solution strategies, and mathematical reasoning (Boesen et al., 2010; Tarr et al., 2008; Ubuz & Sarpkaya, 2014). Therefore, the Grade 6 textbooks appear to provide more frequent opportunities for conceptually connected mathematical work than the Grade 5 textbooks.

The findings also show that high-level demand was not distributed equally across learning areas. In the Grade 5 textbooks, Numbers and Quantities included a relatively high concentration of low-level demand activities, while Algebraic Thinking with Operations included the strongest emphasis on high-level demand. In the Grade 6 textbooks, high-level demand was dominant across all learning areas, yet Doing Mathematics activities were still unevenly distributed. This pattern suggests that the analyzed textbooks provide substantial opportunities for conceptually connected work, while open-ended and non-algorithmic inquiry remains less visible.

The limited presence of Doing Mathematics activities is one of the most important findings of the study. In the analyzed textbooks, Doing Mathematics activities accounted for only 5.6% of Grade 5 activities and 9.8% of Grade 6 activities. This pattern may reflect a textbook design preference for activities with clearly specified procedures, solution paths, and expected answers, which can be more easily organized within curriculum objectives and instructional time. The uneven distribution across learning areas may also be related to differences in how mathematical content is represented. Learning areas such as geometry, statistics, and probability may provide more immediate opportunities for exploration, multiple representations, and alternative strategies, whereas Numbers and Quantities

may be structured more frequently around procedural fluency and the consolidation of previously introduced methods. However, this content-dependent distribution means that students' opportunities to engage in complex mathematical inquiry may vary according to the learning area being studied. Doing Mathematics tasks require students to explore relationships, develop and compare strategies, monitor their reasoning, and justify conclusions (Stein et al., 2000). Such tasks are closely related to mathematical inquiry, non-routine problem solving, and students' active participation in constructing mathematical meaning (Henningsen & Stein, 1997; Stein & Smith, 1998). Previous studies on mathematics textbooks in Türkiye have also reported that opportunities for high-level or Doing Mathematics tasks tend to be limited (Engin & Sezer, 2016; Özgeldi & Esen, 2010; Reçber & Sezer, 2018; Ubuz et al., 2010). The present findings are consistent with these concerns, although the study does not directly compare current and previous textbook editions. When these activities are limited or concentrated in particular learning areas, students may have fewer opportunities to formulate conjectures, compare alternative solution strategies, justify generalizations, and regulate their own problem-solving processes across different mathematical topics. Therefore, the low and uneven distribution of Doing Mathematics activities may restrict the development of flexible, autonomous, and transferable mathematical thinking.

5.3. TIMSS cognitive domains and reasoning-oriented opportunities

The second major finding concerns the distribution of textbook activities according to TIMSS cognitive domains. In the Grade 5 textbooks, Reasoning was the most frequent domain, but Knowledge and Application were also substantially represented. In the Grade 6 textbooks, Reasoning was overwhelmingly dominant, while no activity was coded in the Knowledge domain. This finding indicates that the cognitive orientation of the analyzed textbook set becomes more reasoning-centered from Grade 5 to Grade 6. This finding is important because TIMSS emphasizes students' ability to use mathematical knowledge, apply it in problem situations, and reason with it through analysis, inference, generalization, and justification (Mullis & Martin, 2017; Mullis et al., 2020). Reasoning-oriented tasks are also aligned with the broader goals of mathematics education, which include developing students' problem-solving, communication, and mathematical thinking skills (Olkun & Toluk, 2003; Van de Walle et al., 2016). Therefore, the strong presence of reasoning activities in the Grade 6 textbooks can be interpreted as a meaningful opportunity for supporting higher-order mathematical thinking. The predominance of reasoning-oriented activities can be viewed as a positive feature in terms of supporting higher-order thinking. At the same time, the absence of Knowledge tasks and the limited number of Application tasks in the Grade 6 textbooks indicate that the distribution of TIMSS domains should also be considered in terms of balance. A textbook set that emphasizes reasoning strongly may still need a coherent distribution of knowledge, application, and reasoning tasks according to grade level, learning area, and instructional purpose. Therefore, the issue is not simply increasing the number of reasoning tasks; the key issue is designing a balanced sequence of cognitive opportunities that supports students' movement from foundational knowledge to application and reasoning.

The learning-area findings also show that TIMSS cognitive domains were not distributed evenly across content strands. In the Grade 5 textbooks, reasoning was especially prominent in Algebraic Thinking with Operations and the Statistical Research Process, while Geometric Quantities was mainly application-oriented. In the Grade 6 textbooks, reasoning was dominant in every learning area, particularly in Geometric Quantities and the Statistical Research Process. These findings suggest that reasoning opportunities are present across the Grade 6 textbook set, while the Grade 5 textbooks show a more area-dependent distribution.

5.4. Relationship between cognitive demand levels and timss cognitive domains

The relationship between cognitive demand levels and TIMSS cognitive domains is central to interpreting the findings. The cognitive demand framework focuses on the depth and complexity of the mathematical work required by a task (Stein et al., 2000), whereas the TIMSS cognitive domains framework focuses on the type of cognitive process required for solving a task, such as knowing, applying, or reasoning (Mullis & Martin, 2017; Mullis et al., 2020). This distinction is important because a task with high cognitive demand does not necessarily belong to the TIMSS Reasoning domain. For instance, a Procedures With Connections task may be coded as Application when students use mathematical relationships in a familiar situation, or as Reasoning when they are expected

to justify, infer, or generalize. This interpretation is consistent with the view that textbook tasks shape students' opportunities to learn by structuring both the level and the nature of mathematical engagement (Schmidt et al., 2001; Törnroos, 2005). In this study, the frequent co-occurrence of high-level demand and TIMSS Reasoning, especially in the Grade 6 textbooks, suggests that many activities combine conceptual connectedness with reasoning processes. However, the limited number of Doing Mathematics activities indicates that reasoning-oriented tasks do not always provide open-ended and non-algorithmic inquiry opportunities.

This distinction is important for textbook evaluation. If only cognitive demand levels were examined, the analysis would show the degree of cognitive complexity but would not fully specify whether tasks emphasized knowledge, application, or reasoning. If only TIMSS cognitive domains were examined, the analysis would identify the type of cognitive process but would not fully capture the depth of mathematical work required from students. Using both frameworks made it possible to describe textbook activities through two connected dimensions: the depth of cognitive engagement and the nature of the cognitive process. This combined perspective strengthens the interpretation of the findings by showing both how demanding the activities are and what kind of thinking they primarily promote.

5.5. Implications for textbook development and curriculum alignment

The findings have several implications for textbook development and curriculum alignment. First, the limited and uneven distribution of Doing Mathematics activities suggests that future textbooks should include more tasks that require open-ended exploration, strategy development, justification, and non-routine mathematical inquiry. Such tasks can support students' opportunities to experience mathematics as a process of reasoning, investigation, and explanation rather than as a sequence of procedures. This implication is consistent with studies emphasizing the role of cognitively demanding tasks in supporting mathematical reasoning, problem solving, and meaningful learning (Romero et al., 2015; Stein et al., 2000; Tarr et al., 2008; Ubuz & Sarpkaya, 2014). Recent literature on the Türkiye Century Education Model and newly developed mathematics textbooks reflects a growing interest in evaluating these materials from different analytical perspectives. Studies focusing on mathematical connections and NCTM process standards in Grade 5 textbooks indicate that current textbooks are being evaluated not only in terms of content coverage but also in terms of the learning processes and mathematical practices they promote (Altan et al., 2025; İnci Kuzu et al., 2025). Similarly, studies using cognitive demand or TIMSS-related frameworks highlight the need to examine how curriculum documents and textbook tasks support higher-order thinking, reasoning, and students' opportunities to learn mathematics (Güler et al., 2025; Kaplan, 2025; Uzun, 2025). The present study contributes to this emerging line of research by showing how cognitive demand levels and TIMSS cognitive domains can be used together to evaluate the cognitive depth and cognitive process orientation of textbook activities.

Second, the findings indicate a need for a more balanced distribution of high-level cognitive demand across learning areas. In the Grade 5 textbooks, high-level demand was concentrated more strongly in some learning areas, while Numbers and Quantities included a higher proportion of low-level demand activities. In the Grade 6 textbooks, high-level demand was dominant across learning areas, but Doing Mathematics tasks were concentrated in a limited number of strands. Future textbook design should therefore distribute conceptual connections, reasoning, and mathematical inquiry more systematically across grade levels and content strands.

Third, the TIMSS-based findings suggest that textbook design should consider balance among Knowledge, Application, and Reasoning. The reasoning-oriented structure of the Grade 6 textbooks may support higher-order thinking, but the limited presence of knowledge and application tasks may reduce the diversity of cognitive opportunities. A coherent textbook structure should provide opportunities for students to recall and use mathematical knowledge, apply this knowledge in meaningful situations, and reason with it in unfamiliar or complex contexts. This balance is particularly important when textbooks are considered as resources that shape students' opportunity to learn (Schmidt et al., 2001; Törnroos, 2005).

The findings also have implications for interpreting Türkiye's performance in international assessments. The present study does not test a direct relationship between textbook activities and

student achievement in international assessments. However, previous research has shown that textbooks shape students' opportunity to learn and that the alignment between curriculum, textbooks, and assessment expectations is related to educational outcomes (Fan et al., 2013; Polikoff, 2015; Schmidt et al., 2001; Törnroos, 2005). Studies also suggest that cognitive demand levels in textbook tasks may be associated with students' preparation for international mathematics assessments (Yang & Sianturi, 2022). From this perspective, the uneven distribution of cognitive demand levels and TIMSS domains in the present study suggests that students may encounter different types of cognitive opportunities depending on grade level and learning area. This finding supports the need for textbook designs that distribute conceptual connections, application, reasoning, and open-ended inquiry more coherently across the textbook set.

5.6. Concluding remarks

In conclusion, the analyzed Grade 5 and Grade 6 mathematics textbooks include a substantial proportion of activities requiring high-level cognitive engagement. The Grade 6 textbooks show a stronger emphasis on high-level cognitive demand and TIMSS reasoning than the Grade 5 textbooks. This difference reflects a grade-level pattern within the analyzed textbook set. The study does not make a direct claim about improvement over previous textbooks or curricula. The findings also point to two important issues. First, Doing Mathematics activities remain limited in both grade levels, which restricts students' opportunities for open-ended mathematical inquiry and self-regulated problem solving. Second, the distribution of cognitive demand levels and TIMSS cognitive domains varies across grade levels and learning areas. These patterns suggest that the revised textbook set offers many opportunities for conceptual and reasoning-oriented work, while the distribution of these opportunities can be made more balanced and systematic.

Overall, the study contributes to the emerging literature on the Türkiye Century Education Model and revised mathematics textbooks by showing how cognitive demand levels and TIMSS cognitive domains can be used together to examine students' potential opportunities to learn mathematics through textbook activities. Since textbooks play a central role in organizing instructional content and shaping students' opportunity to learn (Schmidt et al., 2001; Törnroos, 2005), the distribution of activity types in textbooks has important implications for the quality of mathematical learning opportunities. The findings suggest that future textbook development should focus on balancing conceptual connections, application, reasoning, and open-ended mathematical inquiry across grade levels and learning areas. Such a balance may support richer mathematical engagement by providing students with opportunities to recall and use mathematical knowledge, apply it in meaningful contexts, reason with it, and explore mathematical relationships through non-routine tasks.

6. Limitations and Recommendations

6.1. Limitations

The present study has several limitations. First, the analysis was limited to the printed Grade 5 and Grade 6 mathematics textbooks developed within the scope of the current curriculum. Therefore, the findings represent the cognitive profile of the analyzed textbook set and cannot be generalized to other grade levels or to the complete vertical structure of the mathematics curriculum. Second, the study examined textbook activities as written and did not investigate how these activities were implemented in classrooms. The cognitive demand of a mathematical task may be maintained, reduced, or enhanced through teachers' instructional decisions, questioning strategies, and interactions with students. Accordingly, the findings describe the potential learning opportunities offered by the textbooks rather than the opportunities students actually experienced during instruction. Third, the study was based on a descriptive analysis of cognitive demand levels and TIMSS cognitive domains. Although this approach provided a systematic account of the cognitive characteristics of the activities, it did not reveal how teachers interpreted the activities, how students engaged with them, or whether the activities influenced students' mathematical achievement, reasoning, or problem-solving performance. Therefore, no causal relationship can be established between the characteristics of the textbook activities and student learning outcomes.

6.2. Recommendations for textbook design and classroom practice

Based on the findings, textbook developers should increase the number of Doing Mathematics activities, particularly in learning areas where such activities were rare or absent. These activities should provide students with opportunities to explore mathematical relationships, formulate conjectures, compare alternative strategies, justify conclusions, and solve non-routine problems. The distribution of cognitive demand should also be considered across learning areas. In Grade 5, particular attention should be given to learning areas such as Numbers and Quantities, where lower-level activities were more prominent. High-level activities should be distributed systematically across content strands so that students' opportunities for conceptual understanding and mathematical inquiry do not depend primarily on the learning area being studied. Textbook activities should also reflect a coherent progression across the TIMSS Knowledge, Application, and Reasoning domains. The strong emphasis on Reasoning in Grade 6 represents an important cognitive opportunity; however, activities should be sequenced in ways that enable students to recall relevant mathematical knowledge, apply it in meaningful contexts, and use it in reasoning, generalization, and justification processes. Teacher guides may include implementation prompts, extension questions, alternative solution strategies, and suggestions for classroom discussion. Such guidance may help teachers preserve or enhance the intended cognitive demand of activities during instruction and support students' engagement in conceptual reasoning and mathematical inquiry.

6.3. Recommendations for future research

Future studies should examine mathematics textbooks from additional grade levels to determine whether the cognitive patterns identified in Grades 5 and 6 continue across the broader curriculum. Comparative analyses involving different grade levels, textbook editions, or education systems may also provide evidence regarding the progression and consistency of cognitive opportunities. Further research should investigate how textbook activities are enacted in classroom settings. Classroom observations, case studies, and mixed-method studies involving teachers and students may clarify how instructional practices influence the cognitive demand of activities and how students respond to different activity types. Future studies may also examine curriculum objectives, textbook activities, assessment tasks, and classroom practices within the same analytical design. Such multi-layered analyses could provide a more comprehensive account of the alignment between the intended curriculum, instructional materials, implemented curriculum, and assessment practices. Studies examining the relationship between activity characteristics and students' reasoning, problem-solving, and achievement outcomes would provide additional evidence regarding the educational effects of textbook design.

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References

Akpunar, B. (2011). The analysis of the concepts of cognition and metacognition in terms of the philosophy of mind. *Electronic Turkish Studies, 6*(4), 353–365. https://doi.org/10.7827/TurkishStudies.2241

Akyüz, G. (2006). Investigation of the effect of teacher and class characteristics on mathematics achievement in Turkey and European union countries. *Elementary Education Online, 5*(2), 75–86. https://izlik.org/JA82FH97HU

Altan, A., Topuz, F., Özdemir, A. Ş., & Bahadır, E. (2025). Türkiye Yüzyılı Maarif Modeli 5. sınıf matematik ders kitaplarındaki etkinliklerin Amerikan Ulusal Matematik Öğretmenleri Konseyi süreç standartları ile analizi. *İstanbul Eğitim Dergisi, 3*, 337–365. https://doi.org/10.71270/istanbulegitim.istj.1809161

Altun, M., Arslan, Ç., & Yazgan, Y. (2004). Lise matematik ders kitaplarının kullanım şekli ve sıklığı. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 17*(2), 131–147. https://izlik.org/JA97PP53CD

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Arslan, S., & Özpınar, İ. (2009). İlköğretim 6. sınıf matematik ders kitaplarının öğretmen görüşleri doğrultusunda değerlendirilmesi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 12*, 97–113. https://izlik.org/JA95BE73MG

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston.

Basyal, D., Jones, D. L., & Thapa, M. (2023). Cognitive demand of mathematics tasks in Nepali middle school mathematics textbooks. *International Journal of Science and Mathematics Education, 21*(3), 863–879. https://doi.org/10.1007/s10763-022-10269-3

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. David McKay.

Boesen, J., Lithner, J., & Palm, T. (2010). The relation between types of assessment tasks and the mathematical reasoning students use. *Educational Studies in Mathematics, 75*(1), 89–105. https://doi.org/10.1007/s10649-010-9242-9

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Bozkurt, A. (2012). Mathematics teachers' perceptions of mathematical activities. *Education and Science, 37*(166), 101–115. https://doi.org/10.15390/ES.2012.1081

Chapman, O. (2013). Mathematical-task knowledge for teaching. *Journal of Mathematics Teacher Education, 16*(1), 1–6. https://doi.org/10.1007/s10857-013-9234-7

Cihan, F., & Doruk, M. (2024). Evaluation of 2024 high school mathematics curriculum according to SOLO taxonomy and cognitive demand levels. *Usak University Journal of Educational Research, 10*(3), 144–157. https://doi.org/10.29065/usakead.1511690

Cil, O. (2022). A comparative exploration of Turkish and Irish curricula via TIMSS cognitive domains. *Issues in Educational Research, 32*(2), 434–452. http://www.iier.org.au/iier32/cil.pdf

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Delil, A., Özcan, B. N., & Işlak, O. (2020). İlkokul matematik dersi öğretim programı kazanımlarının TIMSS-2019 değerlendirme çerçevesine göre analizi. *Manisa Celal Bayar Üniversitesi Sosyal Bilimler Dergisi, 18*(1), 270–282.

Demirel, Ö., & Kıroğlu, K. (2006). *Konu alanı ders kitabı incelemesi*. Öğreti Yayınları.

Doyle, W. (1983). Academic work. *Review of Educational Research, 53*(2), 159–199. https://doi.org/10.3102/00346543053002159

Engin, Ö., & Sezer, R. (2016). 7. sınıf matematik ders kitabındaki ve programdaki etkinliklerin bilişsel istem düzeylerinin karşılaştırılması. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi, 42*, 24–46. https://izlik.org/JA82PT25YX

Erbaş, A., Alacacı, C., & Bulut, M. (2012). Türk, Singapur ve Amerikan matematik ders kitaplarının bir karşılaştırılması. *Kuram ve Uygulamada Eğitim Bilimleri, 12*(3), 2311–2330.

Fan, L., & Zhu, Y. (2007). Representation of problem-solving procedures: A comparative look at China, Singapore, and US mathematics textbooks. *Educational Studies in Mathematics, 66*(1), 61–75. https://doi.org/10.1007/s10649-006-9069-6

Fan, L., Zhu, Y., & Miao, Z. (2013). Textbook research in mathematics education: Development status and directions. *ZDM, 45*(5), 633–646. https://doi.org/10.1007/s11858-013-0539-x

Forster, N. (1995). The analysis of company documentation. In C. Cassell & G. Symon (Eds.), *Qualitative methods in organizational research: A practical guide* (pp. 207–222). Sage.

Güler, Z., Zengin, Y., Şimşek, A., Akıncı, B., Kanpolat, T., & Lüle, N. (2025). *Türkiye Yüzyılı Maarif Modeli matematik ve fen bilimleri dersleri öğretim programlarının TIMSS 2027 bilişsel alanlarına göre incelenmesi*. Board of Education–Turkish Ministry of National Education.

Güner, N. (2015). 6.-8. sınıf matematik ders kitaplarındaki geometri, veri ve olasılık sorularının TIMSS bilişsel düzeylerine göre sınıflandırılması. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 37*(37), 77–90. https://izlik.org/JA63NU95BM

Harries, A., Sutherland, R. J., Winter, J. C., & Dewhurst, H. (1998). *A comparison of primary mathematics text books from five countries with a particular focus on the treatment of number* (Final report). The Qualifications and Curriculum Authority.

Henningsen, M., & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for Research in Mathematics Education, 28*(5), 524–549. https://doi.org/10.5951/jresematheduc.28.5.0524

Hoque, M. E. (2016). Three domains of learning: Cognitive, affective and psychomotor. *The Journal of EFL Education and Research, 2*(2), 45–52.

Horzum, T., & Duran, A. A. (2024). An examination of the cognitive demand levels posed by problems in the middle grades mathematics textbooks. *International Journal of Educational Spectrum, 6*(2), 294–321. https://doi.org/10.47806/ijesacademic.1522050

İnci Kuzu, Ç., Biber, A. Ç., & Uzun, M. (2025). Türkiye Yüzyılı Maarif Modeli 5. sınıf matematik ders kitabının matematiksel ilişkilendirme açısından incelenmesi. *19 Mayıs Sosyal Bilimler Dergisi, 6*(4), 1–14. https://doi.org/10.52835/19maysbd.1782328

İncikabı, L., Arıkan, S., Delice, A., & Özcan, Z. Ç. (2016). Ortaokul matematik dersi öğretim programı kazanımlarının TIMSS bilişsel alanlarına göre değerlendirilmesi. *İlköğretim Online, 15*(4), 1149–1163. https://doi.org/10.17051/io.2016.54792

Kaplan, O. (2025). Does algebra curriculum develop cognitively advanced critical minds? Comparative analysis of Türkiye and the U.S. mathematics textbooks. *Elektronik Sosyal Bilimler Dergisi, 24*(3), 1297–1320. https://doi.org/10.17755/esosder.1592018

Kıryak, Z., Kozaklı Ülger, T., Ülger, B. B., Bozkurt, I., & Çepni, S. (2024). 2018 ve 2024 ilk ve ortaokul fen bilimleri ve matematik dersleri öğretim programları öğrenme çıktılarının karşılaştırılması ve beceriler açısından incelenmesi. *Bayburt Eğitim Fakültesi Dergisi, 19*(44), 3054–3089. https://doi.org/10.35675/befdergi.1507283

Lessani, A., Md Yunus, A. S., Ahmad Tarmizi, R., & Mahmud, R. (2014). Investigating the content of mathematics textbook used in 8th grade in Malaysia based on content domain of TIMSS. *International Journal of Education and Research, 2*(9), 71–84.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

MacDonald, J. (2008). *Blended learning and online tutoring: Planning learner support and activity design* (2nd ed.). Gower Publishing.

Ministry of National Education. (2024). *PISA 2022 Türkiye raporu*. Millî Eğitim Bakanlığı.

Ministry of National Education. (2025a). *Ortaokul ve İmam Hatip Ortaokulu matematik 5. sınıf ders kitabı (1. kitap) [Middle school and Imam Hatip middle school mathematics Grade 5 textbook (Book 1)]*. https://tymm.meb.gov.tr/upload/kitap/matematik_5_1.pdf

Ministry of National Education. (2025b). *Ortaokul ve İmam Hatip Ortaokulu matematik 5. sınıf ders kitabı (2. kitap) [Middle school and Imam Hatip middle school mathematics Grade 5 textbook (Book 2)].* https://tymm.meb.gov.tr/upload/kitap/matematik_5_2.pdf

Ministry of National Education. (2025c). *Ortaokul ve İmam Hatip Ortaokulu matematik 6. sınıf ders kitabı (1. kitap) [Middle school and Imam Hatip middle school mathematics Grade 6 textbook (Book 1)].* https://tymm.meb.gov.tr/upload/kitap/matematik_6_1.pdf

Ministry of National Education. (2025d). *Ortaokul ve İmam Hatip Ortaokulu matematik 6. sınıf ders kitabı (2. kitap) [Middle school and Imam Hatip middle school mathematics Grade 6 textbook (Book 2)]*. https://tymm.meb.gov.tr/upload/kitap/matematik_6_2.pdf

Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). *TIMSS 2019 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College.

Mullis, I. V. S., Martin, M. O., Goh, S., & Cotter, K. (Eds.). (2016). *TIMSS 2015 encyclopedia: Education policy and curriculum in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College.

Namlı, Ş., & Özçakır, B. (2024). Analysing the tasks in middle school mathematics textbooks according to the levels of cognitive demand. *Türk Akademik Yayınlar Dergisi (TAY Journal), 8*(3), 477–502. https://izlik.org/JA58GM62HU

Nicol, C., & Crespo, S. (2006). Learning to teach with mathematics textbooks: How preservice teachers interpret and use curriculum materials. *Educational Studies in Mathematics, 62*, 331–355. https://doi.org/10.1007/S10649-006-5423-Y

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing.

Olkun, S., & Toluk, Z. (2003). *Matematik öğretimi*. Anı Yayıncılık.

Özgeldi, M., & Esen, Y. (2010). Analysis of mathematical tasks in Turkish elementary school mathematics textbooks. *Procedia - Social and Behavioral Sciences, 2*(2), 2277–2281. https://doi.org/10.1016/j.sbspro.2010.03.322

Palacios, L. A. R., & García, L. M. C. (2018). Cognitive demand for educational standards and textbooks for algebra teaching in Honduras. *Bolema: Boletim de Educação Matemática, 32*, 1134–1151. https://doi.org/10.1590/1980-4415v32n62a19

Pekkan, T., & Esmer, M. (2020). Matematik etkinliklerinin ortak özellikleri. In Y. Dede, M. F. Doğan, & F. Aslan Tutak (Eds.), *Matematik eğitiminde etkinlikler ve uygulamalar* (pp. 77–95). Pegem Akademi.

Piaget, J. (1970). *Science of education and the psychology of the child*. Orion Press.

Polat, S., & Dede, Y. (2022). Trends in the cognitive demand levels of the attainments of Algebra learning domain in the middle school mathematics curriculum. *Ondokuz Mayıs University Journal of Education, 41*(1), 223–274.

Polikoff, M. S. (2015). How well aligned are textbooks to the common core standards in mathematics? *American Educational Research Journal, 52*(6), 1185–1211. https://doi.org/10.3102/0002831215584435

Reçber, H., & Sezer, R. (2018). Cognitive demand levels of tasks in 8th grade textbook and mathematics program. *Ankara University Journal of Faculty of Educational Sciences, 51*(1), 55–76. https://doi.org/10.30964/auebfd.405848

Remillard, J. T. (2000). Can curriculum materials support teachers' learning? Two fourth-grade teachers' use of a new mathematics text. *Elementary School Journal, 100*(4), 331–350. https://doi.org/10.1086/499645

Romero, I. M., del Mar García, M., & Codina, A. (2015). Developing mathematical competencies in secondary students by introducing dynamic geometry systems in the classroom. *Education and Science, 40*(177), 43–58. https://doi.org/10.15390/EB.2015.2640

Satmaz, I., & Yabanova, U. (2024). Analysis of Türkiye Century Maarif Model secondary school mathematics curriculum according to SOLO taxonomy. *International Journal of Curriculum and Instructional Studies, 14*(2), 195–219. https://doi.org/10.31704/ijocis.1582857

Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H., Wiley, D. E., Cogan, L. S., & Wolfe, R. G. (2001). *Why schools matter: A cross-national comparison of curriculum and learning*. Jossey-Bass.

Sevimli, E., & Kul, Ü. (2015). Matematik ders kitabı içeriklerinin teknolojik uygunluk açısından değerlendirilmesi: Ortaokul örneği. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 9*(1), 308–331. https://doi.org/10.17522/nefefmed.11253

Sönmez, M. T. (2017). Analysis of questions about fractions in the fifth grade mathematics textbooks with respect to TIMSS cognitive process skills levels. *Journal of Computer and Education Research, 5*(9), 61–73. https://izlik.org/JA29FG43WF

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation, 2*(1), 50–80. https://doi.org/10.1080/1380361960020103

Stein, M. K., & Smith, M. S. (1998). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School, 3*(4), 268–275. https://doi.org/10.5951/MTMS.3.4.0268

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development*. Teachers College Press.

Sümen, Ö. Ö. (2021). Dördüncü sınıf matematik çalışma kitabında yer alan soruların TIMSS sınavı bağlamında incelenmesi. *OPUS International Journal of Society Researches, 18*(Eğitim Bilimleri Özel Sayısı), 4107–4125. https://doi.org/10.26466/opus.927449

Tarr, J. E., Reys, R. E., Reys, B. J., Chávez, Ó., Shih, J., & Osterlind, S. J. (2008). The impact of middle-grades mathematics curricula and the classroom learning environment on student achievement. *Journal for Research in Mathematics Education, 39*(3), 247–280.

Taşpınar Şener, Z., & Kılıç Bulut, A. H. S. (2022). An analysis of the 4th and 8th grade mathematics textbooks by TIMSS cognitive domains. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 23*(Özel Sayı), 46–83.

Törnroos, J. (2005). Mathematics textbooks, opportunity to learn and student achievement. *Studies in Educational Evaluation, 31*(4), 315–327. https://doi.org/10.1016/j.stueduc.2005.11.005

Ubuz, B., & Sarpkaya, G. (2014). İlköğretim 6. sınıf cebirsel görevlerin bilişsel istem seviyelerine göre incelenmesi: Ders kitapları ve sınıf uygulamaları. *İlköğretim Online, 13*(2), 594–606.

Ubuz, B., Erbaş, A., Çetinkaya, B., & Özgeldi, M. (2010). Exploring the quality of the mathematical tasks in the new Turkish elementary school mathematics curriculum guidebook: The case of algebra. *ZDM Mathematics Education, 42*(5), 483–491. https://doi.org/10.1007/s11858-010-0258-5

Uzun, B. (2025). *Analyzing the levels of cognitive demand in probability tasks: The Turkish 9th-grade mathematics textbook* [Master's thesis, Middle East Technical University].

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2016). *Elementary and middle school mathematics*. Pearson Education UK.

von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. Falmer Press.

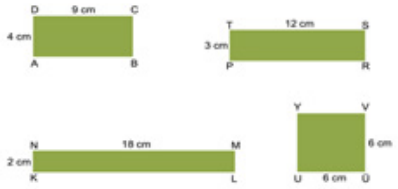
Yang, D. C., & Sianturi, I. A. J. (2022). Analysis of algebraic problems intended for elementary graders in Finland, Indonesia, Malaysia, Singapore, and Taiwan. *Educational Studies, 48*(1), 75–97. https://doi.org/10.1080/03055698.2020.1740977

Appendix A

Example Coding of Activities by Cognitive Demands and TIMSS Cognitive Domains

Theme	*Activity*	*Explanation*
Memorization	Ideal weight is defined as the weight range a person should have based on their height and gender. To stay in the ideal weight range, it is very important to eat a balanced diet and exercise regularly. Elif, Rana, Yusuf, and Selim have weighed themselves to determine whether they are within the ideal weight range. You have learned that decimal representations are just another way of expressing fractions. So, write each measurement result in fractional form and then arrange them in order from largest to smallest using the appropriate symbol. The weights are: ●Elif: 23.4 kg ● Rana: 23.40 kg ● Yusuf: 21.55 kg ● Selim: 21.6 kg Arrange these weights from largest to smallest.	This activity does not require conceptual analysis, strategy development, or alternative solutions, as it only expects the student to perform operations and sorting using the transformation knowledge previously learned.
Procedures Without Connections	Selin and Tugay went to two different markets and compared the prices of the products they wanted to buy. They decided to shop at the market where the products were cheaper. The prices of the products are as: ● Milk: 22.10 TL in Market A, 21.99 TL in Market B ● Oil: 178.75 TL in Market A, 178.50 TL in Market B ● Tea: 90.25 TL in Market A, 90.50 TL in Market B ● Butter: 239.50 TL in both Market A and Market B Now answer the following questions: In which market is milk cheaper? Are there any products with the same price in both markets? If yes, which product(s) and what is the price? In which market is tea more expensive? Selin shops at Market A, and Tugay shops at Market B, both buying oil, tea, and butter. Calculate the total cost for each of them using the prices above and then compare their totals.	This activity does not require higher-level cognitive processes such as establishing conceptual relationships, making inferences, or providing explanations, as it necessitates the performance of specific and simple operations to reach the correct answer.
Procedures With Connections	Teacher Kübra showed the students the pattern in the first three steps as in the figure and asked how many triangles there would be in the 4th and 35th steps of the pattern. She said they could work in groups, and Osman and Afra started working together. In the 1st step there are 3 triangles, in the 2nd step there are 6, and in the 3rd step there are 9. The triangles increase by 3 at each step. Therefore, in the 4th step, there should be 12 triangles. If we continue adding the same amount at each step, it is easy to find the next numbers. Each step has 3 times the step number. So, we can express the pattern with a rule. Using this rule, we can also find the number of triangles in the 35th step: 35 × 3 = 105 35×3=105 triangles in the 35th step. Based on the conversation between Osman and Afra, answer the following questions: Below is another pattern created with badges. The first three steps are given. Determine the rule of this pattern. Using the rule you found, find how many badges there should be in the 4th and 58th steps of this pattern. Create your own pattern and determine its rule.	This activity enables students to develop a deep thinking process by exploring the relationship between the number of steps and the elements in the shape pattern.

Appendix A(*Continued*)

Doing Mathematics	Materials: Two sheets of acetate paper, a ruler, a pencil Place two acetate sheets randomly on top of each other. Describe the types of angles formed between the lines. When you place the acetate papers on top of each other in different ways, discuss with your friends the different types of angles that may occur depending on the relative positions of the lines. Draw all the possible different situations in the boxes below. Based on your drawings, identify and name the angles formed in each situation, and fill in the chart accordingly.	This activity allows students to understand concepts and develop solution strategies because they need to explore the angles between lines and experiment with different situations.
Knowledge	A pair of scissors in an open position has been modeled using straight lines above. Use a protractor to measure the angles in the figure and answer the following questions. Among the angles shown on the scissors, how many are acute angles and how many are obtuse angles? Among the angles you identified, which angle pairs face in opposite directions (i.e., vertical angles)? Compare the measurements of the angle pairs that face in opposite directions and write your conclusion. Among the angles you identified, write the angle pairs that share a common vertex and one common arm.	This activity is at the knowledge level because it measures students' ability to recognize and classify types of angles.
Application	32 × 10 = 320 32 × 100 = 3200 32 × 1000 = 32,000 Examine the multiplication operations above and observe the numbers being multiplied and the result. Explain the properties you observe in the shortcut multiplication operations above. Write your answer below. Find the results of the operations below using the properties you observed from the shortcut multiplication method. 3 × 10 = 3 × 100 = 3 × 1000 = 56 × 10 = 56 × 100 = 56 × 1000 =	This activity is at the application level because students need to apply the rules and patterns they have learned about multiplication in new operations.
Reasoning	Below are rectangles that have equal areas.  For each of these rectangles: Write the area. Write the lengths of two adjacent sides. Calculate and write the perimeter. Afterward, explain why rectangles with the same area can have different perimeters. Then share and discuss your ideas with your classmates.	This activity is at the reasoning level because it requires students to analyze why the perimeter lengths of rectangles with equal areas are different and to draw conclusions about this situation.