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An Examination of The Cognitive Demand Levels Reflected by Mathematics Tasks in The Middle Grades Mathematics Textbooks

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Abstract

This research investigated the cognitive demand levels of mathematics tasks within the middle school mathematics textbooks endorsed by the Ministry of National Education for the academic year of the 2023-2024. To achieve this, a qualitative research method was utilized, and document analysis was performed. In this direction, the textbooks were analyzed using descriptive analysis. The tasks within the textbooks were examined through the lens of Smith and Stein's (1998) theoretical framework. The findings indicate that the majority of mathematics tasks in middle school mathematics textbooks exhibit a low level of cognitive demand. It was found that over 80% of the tasks fell into the categories of memorization and procedures without connections levels. It has been revealed that tasks at the levels of procedures with connections and doing mathematics, which are high cognitive demand levels, are uncommon. This shows that textbooks do not sufficiently support the potential of students to develop mathematical thinking and problem-solving skills. Based on these results, various suggestions have been made for textbooks. The most important of these suggestions include ensuring that students are cognitively exposed to higher level tasks and increasing the number of tasks that will improve their mathematical thinking skills. Thus, it will be possible for students to have a more effective learning process by deepening their mathematical understanding.

Keywords: cognitive demand levels, mathematics tasks, mathematics textbooks

Ortaokul Matematik Ders Kitaplarında Bulunan Matematik Görevlerinin Yansıttığı Bilişsel İstem Düzeylerinin İncelenmesi

Özet (Türkçe)

Bu çalışmada, Millî Eğitim Bakanlığı'nın 2023-2024 eğitim-öğretim yılında kullanılması önerilen ortaokul matematik ders kitaplarında yer alan matematik görevlerinin bilişsel istem düzeyleri incelenmiştir. Bu amaçla nitel araştırma yöntemi benimsenmiş ve doküman analizi yapılmıştır. Bu doğrultuda ders kitapları betimsel analiz kullanılarak analiz edilmiştir. Ders kitaplarında yer alan görevler Smith ve Stein'in (1998) teorik çerçevesi kullanılarak analiz edilmiştir. Bulgular, ortaokul matematik ders kitaplarındaki matematik görevlerinin çoğunun düşük düzeyde bilişsel istem içerdiğini göstermektedir. Görevlerin %80'den fazlasının ezberleme ve ilişkisiz işlemler düzeyinde olduğu belirlenmiştir. Bilişsel istem düzeyi yüksek olan ilişkili işlemler ve matematik yapma düzeylerindeki görevlerin nadir olduğu ortaya çıkmıştır. Bu durum ders kitaplarının öğrencilerin matematiksel düşünme ve problem çözme becerilerini geliştirme potansiyelini yeterince desteklemediğini göstermektedir. Bu sonuçlardan yola çıkarak ders kitaplarına yönelik çeşitli önerilerde bulunulmuştur. Bu önerilerden en önemlileri öğrencilerin bilişsel olarak daha yüksek düzeyde görevlere maruz kalmalarının sağlanması ve matematiksel düşünme becerilerini geliştirecek görevlerin sayısının artırılmasıdır. Böylece öğrencilerin matematiksel anlamaları derinleşerek daha etkili bir öğrenme süreci geçirmeleri mümkün olacaktır.

Anahtar Kelimeler: bilişsel istem düzeyleri, matematik görevleri, matematik ders kitapları

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Introduction

Mathematics education is widely recognized as foundational to the development of critical thinking and problem-solving skills (National Council of Teachers of Mathematics, 2000), making its role in students' academic growth indispensable. While this discipline is crucial, students' struggles in mathematics, often linked to anxiety, disinterest, and a lack of foundational knowledge (Ashcraft & Krause, 2007), underscore the need for effective instructional strategies. These challenges necessitate the exploration of innovative instructional strategies that can transform students' engagement and comprehension in mathematics.

In addressing these educational challenges, such as anxiety and disinterest in mathematics, Cognitive Demand Levels (CDLs) play a pivotal role by structuring mathematics tasks that align with students' cognitive capacities, allowing for an engaging and appropriately challenging learning environment. CDLs, defined as the intellectual challenges that mathematics tasks pose to students (Hsu, 2013), serve as key determinants of learning success by directly influencing the depth and complexity of students' cognitive processes required to think critically, solve problems, and make connections between concepts (Adleff et al., 2023; Barnett et al., 2024; Özkale & Aprea, 2023). However, the effectiveness of tasks with high CDLs can be constrained by factors such as task complexity or insufficient teacher preparedness, which may result in students either becoming overwhelmed by cognitive overload or not being sufficiently challenged (Stein & Smith, 1998; Stylianides & Stylianides, 2008). To maximize the benefits of tasks with high CDLs, it is essential to address these constraints through thoughtful planning and classroom-specific adaptation, ensuring tasks re both intellectually challenging and accessible. This approach ensures that tasks not only challenge but also support students' cognitive development and engagement (Ayres, 2006; Estrella et al., 2020; Polat & Dede, 2023; Wakhata et al., 2023). Ruk (2020) underscores the importance of consistent exposure to tasks requiring high levels of cognitive demands. When implemented thoughtfully, such tasks have been shown to significantly enhance students' conceptual understanding and reasoning skills (Jackson et al., 2013; Hsu & Silver, 2014). As we consider the impact of these cognitive demands, it is essential to explore the variety of resources that effectively support and implement these challenges within the educational context.

To support cognitive demand in mathematics tasks, educators employ various tools and strategies designed to engage students in deeper levels of thinking and problem-solving. These include incorporating historical contexts in mathematics (Agterberg et al., 2022), using worked examples and real-life problems (İncikabı et al., 2023), leveraging online and digital resources (Ekol & Mlotshwa, 2022), focusing on effective task design and implementation (Parrish & Byrd, 2022; Son & Kim, 2015; Takker & Pournara, 2022), and applying assessment frameworks (Ruk, 2020). Among these resources, mathematics textbooks are particularly significant, as they are the primary medium through which mathematics tasks are presented to students (Estrella et al., 2020; Weinberg et al., 2012).

Textbooks play a critical role in structuring cognitive challenges, making the questions they contain deserving of special attention. Specifically, the questions provided at the end of textbook units help reinforce learning and actively involve students in mathematical activities (Raditya et al., 2020). These tasks are vital for assessing students' comprehension and retention of information. Since they are frequently used in assignments, exams, and grading processes, they significantly impact students' learning outcomes and future success (Gillette & Sanger, 2014; Weinberg et al., 2012).

In Türkiye, textbooks are instrumental in defining the educational environment, particularly in standardizing content and teaching practices across various educational contexts. Serving as comprehensive teaching resources, these textbooks not only outline the curriculum but also guide the teaching and learning processes throughout classrooms across the country (Jiang & Li, 2023). It is therefore imperative that the mathematics tasks within these textbooks be carefully selected and structured to enhance students' cognitive skills. This study aims to evaluate the complexity and variety of CDLs of mathematics tasks in middle school mathematics textbooks in Türkiye. The findings are expected to provide valuable insights that can influence the design and development of textbooks and inform pedagogical strategies in mathematics education. Additionally, this study will offer guidance to mathematics teachers on selecting question types that effectively enhance students' cognitive development.

The Importance of Mathematics Textbooks

Mathematics textbooks significantly impact the academic, cognitive, and affective development of students and also influence the professional practices of instructors. These textbooks not only streamline teachers' lesson planning and instructional processes but also furnish students with essential learning resources and a variety of problem-solving strategies, thereby serving dual roles in educational settings (Wijaya et al., 2015).

From the teachers' perspective, mathematics textbooks are crucial for establishing curriculum objectives and providing the necessary resources to achieve these goals. A well-structured textbook saves planning time and supplies comprehensive, up-to-date content that supports effective teaching (Remillard, 2005). Furthermore, by offering diverse methodologies and updated pedagogical content, textbooks assist instructors in refining their teaching practices, as illustrated by Ball & Cohen (1996) who documented how teachers enhance their pedagogical knowledge and employ strategies to increase student achievement through textbook utilization.

Turning to the students' perspective, mathematics textbooks prove invaluable in enhancing academic achievement and developing cognitive abilities. Research has shown that textbooks significantly impact students' learning experiences and outcomes (Jiang & Li, 2023; Sievert et al., 2019). These resources facilitate students' understanding and application of mathematical concepts and subjects through structured learning paths and diverse problem-solving exercises (Bayazıt, 2013; Ismail & Rosli, 2022; Peng & Song, 2015). Moreover, the textbooks' varied exercises and activities significantly boost students' problem-solving skills, as supported by recent studies (Incikabı et al., 2023; Jiang & Li, 2023). The studies also underscore the importance of competency-based teaching methods in textbooks, emphasizing the need for quality tasks that incorporate complexities, open-ended problems, and real-life connections, which are crucial for developing robust problem-solving skills (Fukuda & Manalo, 2022; Hussain, 2018; Jiang & Li, 2023). Problem-based learning resources, noted for increasing students' proficiency in mathematical problem-solving, underscore textbooks' role in enhancing these abilities (Purba & Riskyka, 2021), while the inclusion of problem-posing activities is recognized as a strategy for promoting critical thinking (Deringöl & Guseinova, 2022).

Moreover, textbooks play a critical role in fostering students' cognitive development by developing analytical thinking and logical reasoning, alongside enhancing problem-solving skills (Boston & Smith, 2011; Incikabi et al., 2023; Lee, 2022; Lin, 2023). They shape students' mathematical thinking and influence their conceptual understanding and problem-solving capabilities, providing tasks that require varying levels of cognitive complexity

(Jackson et al., 2013; Incikabi et al., 2023; Lee, 2022). Additionally, real-world problems included in textbooks help students apply mathematical concepts in real-world contexts, further enhancing their problem-solving skills and cognitive development (Incikabi et al., 2023).

In terms of affective development, mathematics textbooks also play a pivotal role in helping students develop positive attitudes towards mathematics. They provide positive feedback and encouraging materials to boost students' achievement and self-confidence, which, in turn, helps reduce fears and anxiety about mathematics, increasing interest in mathematics lessons (Zan & Martino, 2007).

Given their significant contributions to both teaching and learning, it is crucial for instructors and policymakers to prioritize the quality and content of mathematics textbooks to ensure they meet educational standards and effectively support learning objectives. These textbooks not only offer comprehensive teaching resources and techniques for instructors but also provide students with in-depth learning experiences and advanced problem-solving strategies. Recognizing the vital role that mathematics textbooks play in preparing future scientists and analytical thinkers (Indiyanti et al., 2023; Sunzuma & Luneta, 2023), the quality and substance of these resources should be highly valued by educators and policymakers alike.

The Mathematics Tasks Framework: CDLs

The problems and practice exercises that instructors use in the mathematics classroom are often referred to as mathematics tasks (Hsu, 2013). In this context, a mathematics task represents a designated period during which students are expected to master specific mathematical concepts (Henningsen & Stein, 1997). According to this definition, problems found in textbooks can also be categorized as mathematics tasks. These tasks are fundamental in mathematics education, as they serve to promote mathematical understanding, developing students' competencies, and structure lessons effectively (Borromeo Ferri, 2018; Kaur & Chin, 2022; Radmehr, 2023).

Given their importance, recent scholarly literature has focused heavily on examining these tasks, with many studies utilizing the Bloom Taxonomy framework (Aktan, 2019; Alayont et al., 2022; Köğce & Baki, 2009; Üredi & Ulum, 2020). Bloom's Taxonomy is a widely recognized tool for classifying educational objectives and is instrumental in assessing the difficulty levels of tasks. In addition, there is a growing body of research employing the CDLs framework (Basyal et al., 2022; Bayazıt, 2013; Bozkurt & Yılmaz, 2020; Duran, 2024; Engin & Sezer, 2016; Jones & Tarr, 2007; Reçber & Sezer, 2018; Yükselen & Kepceoğlu, 2021). We have chosen to utilize the CDLs framework in our study due to its ability to provide a more nuanced analysis of the cognitive processes students engage in while completing tasks, offering deeper insights into the complexity of these tasks (Smith & Stein, 1998; Stein & Smith, 1998). This framework is particularly valuable in mathematics education as it allows researchers to delve deeper into the relationship between instructional tasks and student learning, enhancing our understanding of how tasks can be designed to maximize cognitive engagement and facilitate effective learning outcomes (Polat & Dede, 2023).

CDLs, first introduced by Smith and Stein (1998), describe cognitive processes and involved in various structures such as problem situations, materials, and textbooks (Hadar & Ruby, 2019). The concept of CDL is defined as the type and level of thinking that students must perform to successfully carry out an instructional task (Stein et al., 2000). The framework classifies tasks into four levels: memorization (Low-M), procedures without connections

(Low-P), procedures with connections (High-P), and doing mathematics (High-M) (Smith & Stein, 1998; Stein & Smith, 1998). Each level highlights different ways students process information and solve mathematical problems (Stein & Lane, 1996).

While Low-M and Low-P represent low-level cognitive demands, High-P, and High-M are high-level cognitive demands. Low-M level refers to students' ability to remember basic mathematical information, terms, and rules. At this level, students memorize information such as mathematical symbols, definitions, and basic operations. In other words, it is the act of placing mathematical concepts, rules, formulas, and definitions in the mind in a way that can be recalled later, without connecting them with the underlying meanings and remembering this information placed in the mind (Stein et al., 2000). Polat and Dede (2023) offered the following example for the Low-M task, which has a low-level cognitive demand: "*Which of the following is the constant term of* $2a^2 + 3b^2$? *A) 0, B) 2, C) 3, D) 5"*. Low-P, another form of low-level cognitive demand, refers to students' ability to apply mathematical operations without establishing a specific logic or connection. At this level, students follow mathematical procedures but do not fully grasp the conceptual understanding underlying these procedures. In other words, these are methods that do not require the use of mathematical concepts, representations, or relationships related to the subject during application (Stein et al., 2000). Polat and Dede (2023) presented the following example for a Low-P task, which has a low-level cognitive demand: "$\frac{73^2-27^2}{25^2-21^2}$ *What is the result of the operation?*" While low-level cognitive demands such as Low-M and Low-P are crucial for foundational skill development, transitioning to high-level cognitive demands is essential for making connections between concepts, navigating between different representations, engaging in reasoning, and employing complex thinking skills such as problem-solving (Stein et al., 1996; Stein & Lane, 1996).

The first high-level cognitive demand, called High-P, refers to students' ability to solve problems by making connections between mathematical operations. At this level, students understand the relationships between mathematical concepts and procedures and use these relationships in the problem-solving process (Stein et al., 2000). In addition, the problem situation at this level is expected to establish a relationship between previous mathematical knowledge and experiences and the current situation (Ecemiş, 2017). Polat and Dede (2023) suggested that for the High-P task, students could be directed with the question: "Write the appropriate inequality for the expression '*The number of people getting into an elevator should be more than 5*,'" Likewise, the level of High-M refers to students' ability to create new mathematical knowledge and develop solutions to original problems. At this level, students make mathematical discoveries and pose new problems by using their creative and critical thinking skills. This includes the situations that require students to understand mathematical connections that are not clearly expressed and to reach conclusions through their own thinking processes and knowledge (Smith & Stein, 1998). Polat and Dede (2023) suggested that for a High-M task, students could be directed with the question: "*Let us examine the terms of the number pattern given as '1, 4, 9, 16,...' and find the rule of the pattern*."

Purpose and Importance of the Study

Rapid developments in our era necessitate innovations in educational methodologies, particularly in the evolution of mathematics teaching, content and evaluation processes, which are of critical importance (Incikabi et al. 2023). In this context, textbooks play a pivotal role by presenting mathematics tasks to students (Hadar & Ruby, 2019). Charalambous et al. (2010) highlight the significant impact of mathematics textbooks on students' cognitive development and success. Consequently, researchers have extensively examined mathematics textbooks through various theoretical frameworks and perspectives. One key focus has been the mathematics tasks within these textbooks, which are crucial for enriching the teaching process and evaluating both students' and teachers' engagement (Stein et al. 1996; Stein & Smith, 1998). Accordingly, Parrish and Bryd (2022) concluded that the use of cognitively challenging tasks in mathematics classes benefits both educators and learners.

In the literature, the analysis of CDLs of mathematics tasks in textbooks has generally been limited to specific focuses. For instance, studies have concentrated on particular subjects (Bayazıt, 2013; Charalambous et al., 2010; Jones & Tarr, 2007; Ubuz & Sarpkaya, 2014; Yang & Lin, 2015; Yükselen & Kepçeoğlu, 2021), skills (Incikabi et al., 2023; Purba & Riskyka, 2021) or grade levels (Basyal et al., 2023; Bozkurt & Yılmaz, 2020; Ecemiş, 2017; Engin & Sezer, 2016; Lee, 2022; Özgeldi & Esen, 2010; Reçber & Sezer, 2018) evaluated the CDLs of the tasks in mathematics textbooks. Bayazıt (2013), investigating the CDLs of tasks related to ratios in primary school mathematics textbooks in Türkiye, found that only 75% of the tasks were at high-level CDLs, with the remainder at low levels. Similarly, Jones and Tarr (2007) noted that over 85% of the tasks in textbooks on probability required low levels of cognitive demand. Conversely, Yang and Lin (2015) observed that textbooks in Taiwan presented more demanding tasks involving systems of linear equations compared to those in Finland, reflecting higher level of cognitive demands.

Studies have also compared the CDLs of tasks in mathematics textbooks across different grade levels. For example, Basyal et al. (2023) analyzed the mathematical tasks known as exercise problems in the 6th, 7th, and 8th-grade mathematics textbooks provided by the Nepalese government, finding that over 92% of these tasks involved low-levels of cognitive demand, primarily at the 'procedures without connections' level. Özgeldi and Esen (2010) analyzed the CDLs of tasks called explanation tasks and assessment tasks in mathematics textbooks at levels of the 6th, 7th, and 8th-grade and reported similar findings in Turkish textbooks, noting a mismatch between the tasks' level and the objectives of the Turkish Mathematics Curriculum.

Furthermore, comparisons of CDLs across different countries have been conducted in the context of a certain subject (Charalambous et al., 2010; Ecemiş, 2017; Incikabi et al., 2023; Sianturi et al., 2021; Yang & Lin, 2015). Notably, Charalambous et al. (2010) identified significant differences in the CDLs of mathematics tasks related to the addition and subtraction of fractions among textbooks from Cyprus, Ireland, and Taiwan, influenced by varying educational priorities and students' previous experiences. They observed that textbooks from Taiwan typically feature tasks with higher cognitive demands, necessitating more complex problem-solving and reasoning activities compared to their counterparts from Cyprus and Ireland. Sianturi et al. (2021) noted that while Cypriot and Irish mathematics textbooks generally require lower cognitive demands, Taiwanese textbooks frequently emphasize higher cognitive demands across a majority of questions.

In addition, there have been studies comparing the CDL of tasks in the textbooks to those outlined in educational curricula (Engin & Sezer, 2016; Reçber & Sezer, 2018). For example, Reçber and Sezer (2018) discovered that the CDLs of tasks in the eighth-grade textbooks were below the levels specified by the curriculum. Research on existing middle school mathematics textbooks in Türkiye indicates that these textbooks are often analyzed in relation to a specific subject, grade level, or international comparisons, but not all mathematics tasks are comprehensively covered (Bozkurt & Yılmaz, 2020; Incikabi et al., 2023; Yükselen & Kepçeoğlu, 2021).

This study distinguishes itself from previous research by thoroughly examining the end-unit questions as mathematics tasks in all middle school mathematics textbooks aligned with the current curriculum in Türkiye. This approach allows for a comprehensive evaluation of the CDLs of mathematics tasks within these textbooks, as endorsed by the Ministry of National Education [MoNE] for use in public schools.

Method

Research Design

This research examines the CDLs of mathematics tasks in middle school mathematics textbooks approved by the MoNE for use in public schools in Türkiye. We gathered data from middle school-level textbooks recommended for the 2023-2024 academic year. The research was structured according to the basic qualitative research design as described by Merriam (2013). This approach is widely recognized for its effectiveness in educational research, where analysis and interpretation of written content are central (Bowen, 2009).

Study Group and Data Collection

The criterion sampling method was employed during the research process to choose textbooks that met a predetermined set of criteria (Creswell, 2012). These criteria are as follows: (i) the textbook must have received general approval from the MoNE, confirming it meets the educational standards required for use in schools across Türkiye, and (ii) it must also be specifically endorsed by the Ministry of Education for the 2023-2024 academic year to ensure its content is up-to-date and aligned with current curriculum. In this context, the MoNE Turkish Education Board has recommended a total of eight different mathematics textbooks published by four public and four private publishing houses for public secondary schools across Türkiye in 2023. The textbooks were prepared based on the 2018 MoNE mathematics curriculum (2018), and multiple choices are available for each grade level. For the 2023-2024 academic year, it is required for all grade levels to utilize at least one of these textbooks. The textbooks in question were digitally published in PDF format and are accessible through the Education Information Network (Eğitim Bilişim Ağı [EBA]), the official platform used by the Ministry of National Education in Türkiye and were subsequently transferred to cloud systems used by the researchers. These materials can be found on the website www.eba.gov.tr. For this research, the primary source of data consisted of these books, and detailed information about the mathematics textbooks examined is provided in Table 1.

Table 1. Information regarding the middle school mathematics textbooks investigated in the study

	Grades	Private/Official	Publisher
5A	5th grade	Official	MoNE
5B	5th grade	Private	Özgün
6A	6th grade	Official	MoNE
6B	6th grade	Private	Ata
7A	7th grade	Official	MoNE
7B	7th grade	Private	Berkay
8A	8th grade	Official	MoNE
8B	8th grade	Private	Berkay

Data Analysis

Descriptive analysis techniques were implemented to evaluate the textbooks. Data from the descriptive analysis were collated and interpreted based on pre-established themes (Yıldırım & Şimşek, 2016, s.239). During the descriptive analysis, the analysis of the end-unit questions, which are mathematics tasks in each textbook, utilized the Framework of CDLs given in Table 2. Within this specific framework, the analysis of mathematics tasks in textbooks was conducted by adhering to the following phases:

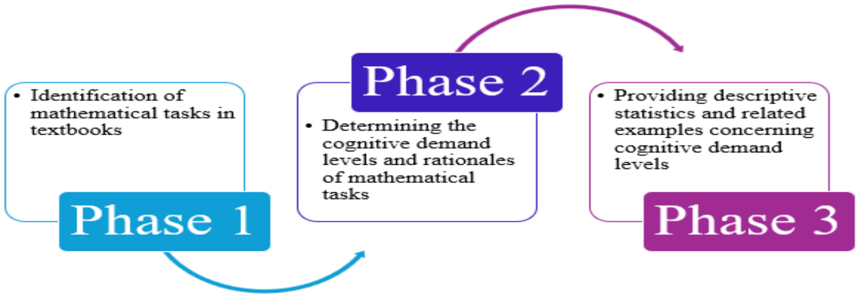


Figure 1: Phases of the analysis process

Identification of Mathematics Tasks in Textbooks: There are six units in each specified textbook, and these units include learning outcomes questions, chapter questions, and end-unit questions. Polat and Dede (2023) state that learning outcome questions encourage students to interpret and apply mathematical concepts on a certain topic, whereas chapter questions involve interpreting, applying, and solving mathematical contents across multiple subjects. End-unit questions evaluate the understanding of the concepts throughout the unit (ibid.). In the current study, end-unit questions were defined as mathematics tasks that students engaged in one-on-one at the end of the unit and then transferred to the cloud system in the common study area. In this way, the units of analysis of the textbooks were obtained. Accordingly, it was determined that there was a total of 886 mathematics tasks in the 5A, 5B, 6A, 6B, 7A, 7B, 8A and 8B textbooks. The specific numbers of tasks in each textbook were 91, 101, 96, 110, 66, 91, 207, and 124, respectively. Tables for each textbook have been created in the cloud system to serve as the basis for the subsequent phase of these tasks.

Determining the CDLs and rationales of mathematics tasks: Mathematics tasks, extracted from a range of textbooks currently in use across various educational levels, were transferred to the cloud system and are associated with page numbers, unit numbers, images, CDLs, and justifications. These tasks are directly taken from textbooks specifically designated as 5A, 5B, 6A, 6B, 7A, 7B, 8A, 8B, providing a broad representation of the curriculum. The textbooks were shared evenly among the researchers, who then independently examined the tasks in the textbooks for which they were responsible and recorded the results in the tables. During this phase, the CDLs framework developed by Smith & Stein (1998) was applied, coding the tasks as Low-M, Low-P, High-P, and High-M, depending on their cognitive demand levels.

Each entry in Table 2 synthesizes these findings, clearly specifying the specific textbooks and tasks analyzed. After this initial evaluation, the researchers critically reviewed each other's analyses and identified points of disagreement. Accordingly, the data analysis revealed agreement-correlation coefficients of 89% in the 5A textbook, 95.1% in the 5B textbook, 91.8% in the 6A textbook, 80.3% in the 7A textbook, and 89% in the 7B textbook. 87.4% in textbook 8A and 87.1% in textbook 8B. These high levels of agreement underscore the reliability of our coding process, as affirmed by Miles and Huberman (2015), and further validate the data presented in Table 2 as a product of our meticulous analysis.

However, the remaining disagreements were resolved in a four-hour face-to-face and one-hour online meeting, and an agreement was reached on the final CDLs and their corresponding justifications. To elucidate, the data represented in Table 2 originates entirely from our team's analysis, reflecting our independent assessment and collaborative consensus. Figure 2 provides an example of a question that was discussed and unanimously agreed upon.

Hasan Bey has a garden in the shape of an equilateral triangle with each side measuring z units. He wants to surround his garden with two rows of wire. Which of the following algebraic expressions represents the length of the wire he will use?

A) 3z B) 6z C) 9z D) 12z

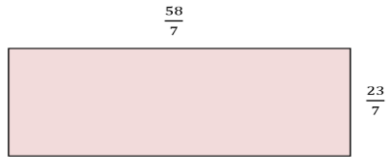
Figure 2: Example of a consensus question (6A)

The CDL of the question presented in Figure 2 led to a difference of opinions among the researchers concerning Low-M and Low-P, and a consensus was reached that it was at the level of Low-M. The problem's solvability within a short timeframe, eliminating the need for procedural action, has shown to be an effective reason for achieving consensus. In this way, after agreement is reached on all conflicting mathematics tasks, CDLs and examples from textbooks are presented in Table 2.

Providing descriptive statistics and related examples concerning CDLs: After determining the CDLs of mathematics tasks for each textbook and each unit, the frequency and percentage distributions of these tasks were calculated for each unit and textbook. These analyses revealed the rates of CDLs in textbooks and units (Table 3). For example, the rate of Low-M level mathematics tasks in the 8A textbook was 49%. However, this rate was 70% in the third unit of the same textbook. Then, examples and explanations of the CDLs of mathematics tasks are given.

Table 2. Analysis Framework of CDLs (Adapted from Smith & Stein, 1998)

	Low-Level Cognitive Demands	Examples / Textbooks	Rationales
Memorization (Low-M)	Involve either reproducing previously learned facts, rules, formulas, or definitions *or* committing facts, rules, formulas, or definitions to memory. Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure. Are not ambiguous. Such tasks involve the exact reproduction of previously seen material, and what is to be reproduced is clearly and directly stated. Have no connection to the concepts or meaning that underlie the facts, rules, formulas, or definitions being learned or reproduced.	Which of the following is the unit fraction of $\frac{18}{25}$? A) $\frac{18}{25}$ B) $\frac{1}{5}$ C) $\frac{1}{25}$ D) $\frac{1}{18}$ (5B) $(-7)^{20}$ $(-1)^{41}$ $(-2)^{8}$ $(-4)^{23}$ $(-13)^{46}$ $(+1)^{8}$ $(+1)^{21}$ $(-8)^{29}$ Determine the signs of the values of the exponential expressions given in the boxes. (7B)	The examples given are at the Low-M level because students can remember the information or definition they learned and solve the question in a short period without the need to use procedures. For the first example, understanding unit fractions is essential, while in the second, knowledge that odd powers of negative integers yield negative results, even powers of negative integers yield positive results, and all powers of positive integers result in positive values, is adequate to answer the question.
Procedures without connections (Low-P)	Are algorithmic. Use of the procedure either is specifically called for or is evident from prior instruction, experience, or placement of the task. Require limited cognitive demand for successful completion. Little ambiguity exists about what needs to be done and how to do it. Have no connection to the concepts or meaning that underlies the procedure being used. Are focused on producing correct answers instead of on developing mathematical understanding Require no explanations or explanations that focus solely on describing the procedure that was used.	If the sum of the coordinates of the ordered pair (2c-1, c+4) is 36, what is c? (8B) -8 | 4 | A 2 | B | -3 D | -7 | C In the table above, the sum of the numbers in each row is written in the right hand side, and the sum of the numbers in each column is written in the underside. Since each letter in the table represents an integer, what is the result of $(A)^{C} + B \, . \, D$? (7A)	The examples given are at the Low-P level because there is no ambiguity in the questions. Students need to solve the question only by processing the information they have learned about the subject. The aim is not to improve students' mathematical understanding but to ensure that they apply the operations correctly and reach the answer. In the first example, it is clearly stated in the question that the unknown must be found by adding two algebraic expressions and equating them to a number. In the second example, it is clearly stated in the question that it is necessary to add the numbers in the same row and write next to them. All students have to do is follow the required procedures correctly.

<table>
<tr><th></th><th>High-Level Cognitive Demands</th><th>Examples / Textbooks</th><th>Rationales</th></tr>
<tr>
<td>Procedures with connections (High-P)</td>
<td>Focus students' attention on the use of procedures to develop deeper levels of understanding of mathematical concepts and ideas.
Suggest explicitly or implicit pathways to follow that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque concerning underlying concepts.
Usually are represented in multiple ways, such as visual diagrams, manipulatives, symbols, and problem situations. Making connections among multiple representations helps develop meaning.
Require some degree of cognitive effort. Although general procedures may be followed, they cannot be followed mindlessly. Students need to engage with conceptual ideas that underlie the procedures to complete the task successfully and that develop understanding.</td>
<td>

In her technology and design class, Ayşe drew and cut the largest possible square from the rectangular carton whose side lengths are given above. This process continued until the smallest square was obtained. Which of the following is the perimeter of the smallest square he obtained?
A) $\frac{1}{7}$ B) $\frac{2}{7}$ C) $\frac{3}{7}$ D) $\frac{4}{7}$ (7A)
Table: Exam Results
<table>
<tr><th>Student Name</th><th>Number of correct answers</th><th>Number of incorrect answers</th></tr>
<tr><td>Cansu</td><td>48</td><td>12</td></tr>
<tr><td>Kerim</td><td>42</td><td>18</td></tr>
</table>
The number of correct and incorrect answers given by Cansu and Kerem in a 60-question exam is indicated in the two-way frequency table above. Show the data in the two-way frequency table in a clustered bar chart. (6B)</td>
<td>The examples given are at the High-P level because the aim is to engage students with conceptual ideas. In the first example, students need to imagine drawing and cutting a piece of caron and continue the process by establishing a relationship between a square and a rectangle. So, it requires some degree of cognitive effort. In the second example, these examples are at the High-P level, since giving a frequency table and creating a bar graph requires the student to make connections between multiple representations.</td>
</tr>
<tr>
<td>Doing Mathematics (High-M)</td>
<td>Require complex and non-algorithmic thinking - a predictable, well-rehearsed approach or pathway is not explicitly suggested by the task, task instructions, or a worked-out example.
Require students to explore and understand the nature of mathematical concepts, processes, or relationships.
Demand self-monitoring or self-regulation of one's cognitive processes.
Require students to access relevant knowledge and experiences and make appropriate use of them in working through the task.
Require students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions.
Require considerable cognitive effort and may involve some level of anxiety for the student because of the unpredictable nature of the solution process required.</td>
<td>On isometric paper, draw two different rectangular prisms and a non-prism structure with a volume of 10 cubic units.

(6B)
Using protractor and ruler, draw a triangle ABC with $m(\widehat{BAC}) = 70°$, $|AB| = |AC| = 3$ cm. What is the $|BC|$ in centimeters in the triangle you drew? Find it by measuring with a ruler. (8B)</td>
<td>The provided examples are classified as High-M level because they demand that students engage in exploring and comprehending the nature of mathematical concepts, processes, or relationships. Moreover, these questions require complex, non-algorithmic thinking. In the first example, students are asked to create the structure themselves, and since there may be more than one drawing, it requires students to self-monitor or organize their cognitive processes. In the second example, students are asked to create a triangle and make measurements based on the information given. Similarly, it requires students to self-monitor or regulate their cognitive processes and is at the level of High-M.</td>
</tr>
</table>

Note: This table presents results generated from our original data analysis applying the CDLs framework. Each entry reflects our analysis of the cognitive demand levels in middle school mathematics textbooks.

Validity and Reliability

The validity of the research was secured through the selection and development of the research topic, informed by a comprehensive review of pertinent literature. The findings of the study were meticulously analyzed and scrutinized. To further reinforce the validity, the research was intentionally conducted during the spring semester of the 2023-2024 academic year. This timing allowed for the inclusion of all eight mathematics textbooks for grades 5-8 recommended by the Ministry of National Education (MoNE) in the study. To further increase validity, the results were expressed using original sentences taken directly from middle school mathematics textbooks, employing a 'thick description' approach as described by Creswell (2012). However, due to copyright restrictions, images from the textbooks were either not included in the study or were recreated by the researchers to appear similar.

To ensure the reliability of the study, researchers analyzed their respective data segments using the Framework of CDLs (Smith & Stein, 1998) to comprehend the data. They then compared and reviewed their codings, identifying points of agreement and disagreement. Disagreements were resolved through detailed discussions about data interpretations. Subsequently, they confirmed the CDLs that were used as the framework for the analysis. The data analysis process was meticulously deliberated in face-to-face and online discussions, spanning five hours until complete consensus was achieved.

Since the data was obtained from written documents, there were no problems regarding privacy and confidentiality. However, great care was taken to ensure that the data analysis and report writing were exclusively centered on the CDLs under investigation, rather than on specific individuals or organizations. No accusations were made against any individuals or organizations.

Ethical consideration

This study analyzed textbooks that are publicly available at www.eba.gov.tr. Consequently, there were no ethical issues associated with the conduct of the research, and there was no requirement for ethics committee approval.

Findings

This section details the findings concerning the CDLs of mathematics tasks in eight middle school mathematics textbooks endorsed by the Ministry of National Education for the academic year of 2023-2024. It is crucial to acknowledge that an initial table (Table 3) displays the CDLs of these duties on a per-unit basis in this context. Then, the contexts of CDLs are explained with examples.

Table 3. CDLs of mathematics tasks in textbooks

		CDLs							
		Low-M		**Low-P**		**High-P**		**High-M**	
Textbook	**Units**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
5A (91 tasks)	Unit 1	4	27%	9	60%	2	13%	0	0%
	Unit 2	7	44%	5	31%	4	25%	0	0%
	Unit 3	6	35%	10	59%	1	6%	0	0%
	Unit 4	7	70%	1	10%	2	20%	0	0%
	Unit 5	6	43%	7	50%	1	7%	0	0%
	Unit 6	8	42%	3	16%	8	42%	0	0%
	Total	***38***	***42%***	***35***	***38%***	***18***	***20%***	***0***	***0%***
5B (101 tasks)	Unit 1	8	40%	11	55%	1	5%	0	0%
	Unit 2	6	31%	11	58%	2	11%	0	0%
	Unit 3	9	69%	4	31%	0	0%	0	0%
	Unit 4	14	70%	4	20%	0	0%	2	10%
	Unit 5	5	29%	10	59%	1	6%	1	6%
	Unit 6	3	25%	3	25%	3	25%	3	25%
	Total	***45***	***44%***	***43***	***43%***	***7***	***7%***	***6***	***6%***
6A (96 tasks)	Unit 1	7	44%	8	50%	1	6%	0	0%
	Unit 2	9	56%	5	31%	2	13%	0	0%
	Unit 3	8	50%	8	50%	0	0%	0	0%
	Unit 4	7	44%	5	31%	4	25%	0	0%
	Unit 5	6	38%	6	38%	3	18%	1	6%
	Unit 6	6	38%	8	50%	2	12%	0	0%
	Total	***43***	***45%***	***40***	***42%***	***12***	***12%***	***1***	***1%***
6B (110 tasks)	Unit 1	9	36%	15	60%	1	4%	0	0%
	Unit 2	8	27%	20	66%	2	7%	0	0%
	Unit 3	3	30%	7	70%	0	0%	0	0%
	Unit 4	3	21%	6	43%	3	21%	2	14%
	Unit 5	7	64%	3	27%	0	0%	1	9%
	Unit 6	8	40%	11	55%	0	0%	1	5%
	Total	***38***	***35%***	***62***	***56%***	***6***	***5%***	***4***	***4%***
7A (66 tasks)	Unit 1	2	13%	12	80%	1	7%	0	0%
	Unit 2	1	9%	8	73%	2	18%	0	0%
	Unit 3	3	43%	4	57%	0	0%	0	0%
	Unit 4	2	14%	9	64%	3	22%	0	0%
	Unit 5	1	10%	5	45%	5	45%	0	0%
	Unit 6	2	25%	1	13%	5	62%	0	0%
	Total	***11***	***17%***	***39***	***59%***	***16***	***24%***	***0***	***0%***
7B (91 tasks)	Unit 1	3	38%	3	38%	2	24%	0	0%
	Unit 2	3	19%	12	75%	1	6%	0	0%
	Unit 3	5	24%	9	43%	6	28%	1	5%
	Unit 4	2	12%	11	65%	4	23%	0	0%
	Unit 5	3	14%	16	76%	2	10%	0	0%
	Unit 6	1	13%	2	25%	5	62%	0	0%
	Total	***17***	***19%***	***53***	***58%***	***20***	***22%***	***1***	***1%***
8A (207 tasks)	Unit 1	12	36%	19	58%	2	6%	0	0%
	Unit 2	12	39%	16	52%	3	9%	0	0%
	Unit 3	28	70%	10	25%	2	5%	0	0%
	Unit 4	16	45%	16	45%	4	10%	0	0%
	Unit 5	18	62%	7	24%	4	14%	0	0%
	Unit 6	16	42%	10	26%	10	26%	2	6%
	Total	***102***	***49%***	***78***	***38%***	***25***	***12%***	***2***	***1%***

8B (124 tasks)	Unit 1	7	50%	7	50%	0	0%	0	0%
	Unit 2	3	20%	10	67%	2	13%	0	0%
	Unit 3	16	69%	5	22%	2	9%	0	0%
	Unit 4	9	36%	8	32%	8	32%	0	0%
	Unit 5	9	37%	10	42%	4	17%	1	4%
	Unit 6	12	52%	5	22%	5	22%	1	4%
	Total	***56***	***45%***	***45***	***36%***	***21***	***17%***	***2***	***2%***
Total (886 tasks)		***350***	***39%***	***395***	***45%***	***125***	***14%***	***16***	***2%***

Note: Here the percentages are rounded

Table 3 shows the variability of the CDLs of mathematics tasks in each middle school mathematics textbook and their related units. This table reveals a clear focus on tasks that require a low level of cognitive demand, with over 80% of the tasks classified as Low-M and Low-P. This tendency manifests itself consistently in all textbooks examined. However, while the emphasis is on Low-M level tasks in the fifth and eighth-grade textbooks as well as the 6A textbook, the seventh-grade textbooks and 6B textbooks focus more on tasks at the Low-P level. For example, Low-M level tasks in the 8A textbook constitute half of the total tasks, and Low-P level tasks in the seventh-grade textbooks constitute approximately 60% of the total tasks. Additionally, the majority of textbook units are highly rated at the Low-P level. For example, while the Low-P level has the highest rate with 80% in the 1st unit of the 7A textbook, the Low-M level, although less common, is observed in the 5th, 6th, and 8th-grade textbooks units. For example, in the 5A textbook, Low-M and Low-P tasks are represented by more than 40% in many units.

Textbooks typically provide a smaller quantity of tasks at high CDLs compared to tasks at low CDLs. Although tasks at the High-P level were generally less common, they accounted for a significant proportion of 62% in the 6th unit of the 7B textbook. Seventh-grade textbooks allocate more space to High-P tasks compared to Low-M tasks. Moreover, 5A and 7A textbooks do not include High-M level tasks, and the few High-M tasks that are included represent a very minor proportion, generally below 10%, of the total tasks in the textbooks.

Table 3 also reveals that the content of each unit differs based on CDLs. For example, in the 6th unit of the 5B textbook, tasks categorized as Low-M, Low-P, High-P, and High-M are distributed balanced. However, it has been observed that in some units, especially in the 3rd unit of the 6B textbook, High-P and High-M level tasks and in the 5th and 6th units of the High-P level tasks are completely missing.

In light of these findings, more detailed explanations for each CDL (Low-M, Low-P, High-P, High-M) regarding the mathematics tasks included in the textbooks are presented along with illustrative examples that exemplify each CDL. Tasks at the Low–M level include questions that require the use or memorization of previously acquired rules, formulas, and definitions, and which generally do not necessitate any procedures or require quite a bit of time to solve. For example, the tasks given in Figure 3 in the 5B textbook exemplify this situation.

In the natural number 6 606 626, which digit has the place value of 600 000?

A) Ones B) Hundreds C) Ten Thousands D) Millions

Which of the following orders is correct?

A) $\frac{1}{17} > \frac{1}{16} > \frac{1}{15}$ B) $\frac{1}{8} > \frac{1}{10} > \frac{1}{12}$

C) $\frac{1}{8} < \frac{1}{22} < \frac{1}{30}$ D) $\frac{1}{3} < \frac{1}{4} < \frac{1}{5}$

Figure 3: Examples of Low-M level tasks (Adapted from textbook 5B, p.69 and p.106 (Source: Authors' illustration)

The first task given in Figure 3, in addition to requiring knowledge of the previously acquired concept of place value and its related properties, has a character that the student can solve without using any operations. Similarly, in the second question, if students know the ordering rule for unit fractions, they can perform this task effortlessly.

Another criterion that Low–M level tasks meet is that they are not ambiguous, involve a precise repetition of previously encountered questions, or explicitly state what is being repeated. For example, the tasks given in Figure 4 in textbooks 7B and 8A exemplify this situation.

$\frac{-7}{5}$ $\frac{5}{7}$ $\frac{7}{-5}$ $-\frac{7}{5}$ $\frac{5}{12}$ $-\frac{5}{7}$

Which of the rational numbers in the boxes are equal?

Which of the lines whose graphs are shown on the coordinate plar below has negative slope?

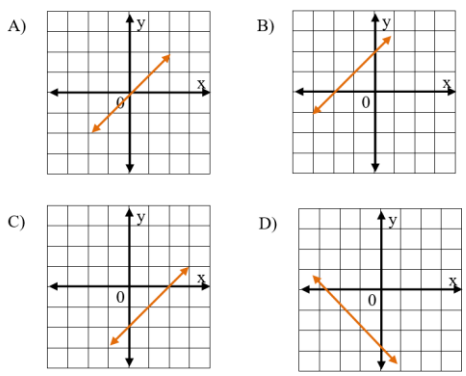


Figure 4: Examples of Low-M level tasks (Adapted from textbook 7B, p.74 and 8A, p.140) (Source: Authors' illustration)

The initial task in textbook 7B, given in Figure 4, requires an awareness of both the negative and positive rational numbers and has a characteristic that can be solved quickly in the mind. Although this task involves the exact repetition of previously encountered questions, it is a task at the Low-M level as it is not related to the concepts underlying formulas, rules, or definitions. Similarly, the second task in the 8A textbook requires knowing in which case the slope of the lines whose graphs are given in the coordinate system is positive and in which case it is negative. Such examples are discussed during the subject teaching at the 8th-grade level and are presented to students as a rule. They can also be solved without the need to use operations.

The tasks at the Low–P level, which are commonly preferred in middle school mathematics textbooks, are predominantly algorithmic problems. These problems specify or assume the operation to be used. based on previous experiences. Additionally, tasks at this level include mathematics tasks in which limited cognitive demand is used to obtain success, with explanations focused solely on the procedure used. For instance, the mathematics tasks indicated in the textbooks, 5A and 6A (shown in Figure 5), and 7B and 8B (shown in Figure 6) represent these mentioned features of Low-P level tasks.

Match the following operations with the results.

$\frac{1}{3}+\frac{2}{6}$	$1\frac{1}{6}+\frac{1}{2}$	$2\frac{3}{8}-1\frac{1}{4}$	$4-\frac{2}{3}$	
$\frac{1}{7}$	$3\frac{1}{3}$	$1\frac{2}{3}$	$\frac{2}{3}$	$1\frac{1}{8}$

The figure on the side consists of a semicircle with center A and diameter [BC].
If |BC| = 20 cm, what is the perimeter of the shape in cm? (use 3,14 for π).

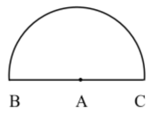


Figure 5: Examples of Low-P level tasks (Adapted from textbook 5A, p.133 and 6A, p.267)
(Source: Authors' illustration)

In the first task outlined in Figure 5, it is sufficient to perform simple one-step operations instead of complex ones. These operations require limited cognitive demand to achieve success. In the second task in the 6A textbook, to determine the perimeter of the shape, the lengths of the semicircle and the diameter must be calculated consecutively and then added. Therefore, there is an algorithmic procedure. Furthermore, there is minimal ambiguity about what should be done and how it should be done to achieve the correct solution to this task.

If the following statements are true, write "D" in the box at the beginning of the statements, if they are wrong, write "Y".

- ☐ 160% of 3000 TL is 4800 TL.
- ☐ 13% of 800 pencils are 114 pencils.
- ☐ 15% of 24 kg of meat is 180 kg.
- ☐ 0.06% of 18 000 m is 300 m.
- ☐ The number that is 250% of 350 is 140.
- ☐ The number 40 is 80% of 50.

Find the results of the following operations.

a. $\frac{(-1)^{14}.\ 3^{22}.\ 2^{-10}}{(3)^{20}.\ 2^{-9}} =$ b. $2^{-2}.\ (-1)^{11}.\ 2^{4} =$ c. $\frac{25\ .\ 5^{4}}{125}$

ç. $\frac{10^{-4}}{2^{-4}} =$ d. $\frac{2^{4}.\ 4^{2}}{6} =$ e. $1{,}08\ .\ 10^{-2}.\ 10^{-3}$

Figure 6: Examples of Low-P level tasks (Adapted from textbook 7B, p.142 and 8B, p.54)
(Source: Authors' illustration)

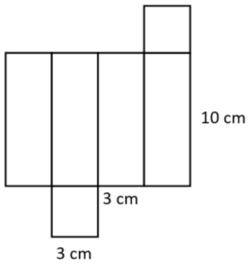
The algorithmic nature of the operations used in the first task in Figure 6, as well as their inclusion in the 7B textbook, results in a solution process that is not laborious. The focus is on generating correct answers and providing explanations for the operations employed. Consequently, the evaluation of the tasks' solution process is classified as Low-P level. On the other hand, the second task in the 8B textbook requires not just explanations of the procedures used but also detailed step-by-step operations.

The primary emphasis of middle school mathematics textbooks was on engaging students in high-level tasks that involved the use of operations to develop a deeper understanding of mathematical concepts and ideas. In addition, it focuses on establishing connections between multiple representations by focusing on broad and general operations rather than basic algorithms. Consequently, these mathematics tasks emerged as opportunities for students to interact with the conceptual ideas underlying the operations. The tasks given in Figure 7 in the 5B and 6A textbooks exemplify this situation.

Employees at a workplace were asked about the television programs they watch most. The frequency table below has been prepared according to the answers received. Create a bar graph on squared paper using the table.

Table: Most Watched TV Programs

Program Type	News	Sport	Documentary	Series	Cartoon
Number of People	10	8	6	12	4



What is the volume of the square prism whose open form and edge lengths are given above in cubic centimeter?

Figure 7: Examples of High-P level tasks (Adapted from textbook 5B, p.222 and 6A, p.233) (Source: Authors' illustration)

The initial task presented in Figure 7 requires fifth-grade students to convert the information provided in the table into a bar graph. Completing this task involves establishing relationships between visual diagrams, and this is, to some extent, the product of a cognitive effort. The second task given at the sixth-grade level provides students with information about the nets and edge lengths of a square prism and asks them to calculate its volume. This task necessitates students to distinguish the concepts of base and height as given by the net and also to relate the information they obtained from this to volume calculation. Therefore, it requires students to establish a connection between the net of a square prism and its volume. This points to the use of operations to cultivate a deep understanding of concepts.

Most High-M level tasks in middle school mathematics textbooks are characterized by complex, non-algorithmic thinking, and demand significant cognitive effort, without offering a predictable approach or solution. These tasks necessitated that students explore and organize the nature of mathematical concepts, processes, or relationships by engaging actively in their processes, thereby gaining an understanding of the underlying nature of these mathematical concepts (Figure 8).

Draw three polygons with perimeter of 16 units on the dot paper below.

The right triangle KLM right hand side is rotated 360° around the side KL to form a right cone. Draw the net of the right cone created (use 3 for π).

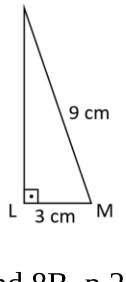


Figure 8: Examples of High-M level tasks (Adapted from textbook 5B, p.222 and 8B, p.279) (Source: Authors' illustration)

The first of the tasks given in Figure 8 is included in the 5B textbook. The objective of this task is for students to draw three polygons with a perimeter of 16 units. In this task, no predictable approach or solution was provided, and students were expected to develop their own ways of solving it. In this process, students will be active at both cognitive and psychomotor levels, so they will spend a significant amount of cognitive effort. The second example in Figure 8 in the 8B textbook is a task that involves constructing a relationship between a specified right triangle and a right cone, followed by the task of drawing the net of this cone. However, this task requires students to imagine a complete rotation of the right triangle 360 degrees to answer the question and to make associations with mental representations, thus understanding the nature of mathematical concepts, processes, and relationships. Then, in the process of drawing the net of this formed shape, students are expected to grasp the nature of mathematical concepts and relationships and follow their processes. This task, which requires being active at the cognitive and psycho-motor level, naturally prompts students to tap into their knowledge and experience and effectively use this information while working on the subject at hand.

Results and Discussion

This research investigated the CDLs of mathematics tasks in eight secondary school mathematics textbooks recommended for use by the MoNE in the academic year of 2023-2024 in Türkiye. In the study, Smith and Stein's (1998) theoretical framework was used to evaluate the CDLs of the end-unit questions at the end of the units in each textbook as mathematics tasks. Determining the CDLs of mathematics tasks in textbooks is crucial for prompting effective mathematics instruction and learning (Incikabi et al., 2023; Polat & Dede, 2023). It is imperative to comprehend the cognitive levels required to tackle mathematical problems to design tasks that appropriately challenge students' thinking skills (Sianturi et al., 2021). Thus, this research contributes uniquely to the dialogue on the role of mathematics tasks in education, underlining how they can inform and shape future educational strategies.

The primary finding of this study is that a majority of the mathematics tasks in middle school mathematics textbooks exhibit a low level of cognitive demand. Notably, most tasks within these textbooks correspond to the Low-P level, which belongs to the low CDLs, indicating a focus on recalling information and performing algorithmic operations. This trend suggests that textbooks predominantly encourage students to produce correct answers rather than fostering a deep understanding of mathematical concepts. These results are consistent with findings from diverse contexts, time periods with different textbooks reported in various studies utilizing the same theoretical framework (Basyal et al., 2023; Charalambous et al., 2010; Jones & Tarr, 2007; Özgeldi & Esen, 2010; Yang & Lin, 2015; Yükselen & Kepceoğlu, 2021). However, there are notable contradictions with other research (Bayazıt, 2013; Charalambous et al., 2010; Engin & Sezer, 2016; Reçber & Sezer, 2018; Sianturi et al., 2021; Ubuz & Sarpkaya, 2014), which may be attributed to variations in educational settings, differences in methodology for assessing cognitive demands, or discrepancies in the interpretation of cognitive demands across different cultural and educational frameworks. According to the Mathematics Curriculum (MoNE, 2018), the curriculum's primary goal is to foster the acquisition of values and skills rather than merely transferring knowledge (p.4). Additionally, one of the key objectives highlights the development of students' metacognitive knowledge and skills to enable conscious management of their learning processes (p. 9). Despite these objectives, the findings from the textbooks analyzed indicate a misalignment with these curriculum goals (Reçber & Sezer, 2018), potentially hindering the development of higher-level cognitive skills like mathematical thinking and problem-solving.

Another notable finding of this study is the relative scarcity of tasks with high levels of cognitive demand in textbooks and grade-levels. While tasks with higher cognitive demand are more prevalent in some textbooks and grade-levels, such tasks generally remain in the minority. In particular, tasks at the High–-M level—representing the most complex CDLs—are almost entirely absent. This lack of emphasis on more challenging tasks limit opportunities for students to engage in substantial mathematical thinking. Such tasks are critical as they provide students with opportunities to develop higher-order thinking skills, an essential component of meaningful mathematics learning (Stein et al., 1996; Stein & Smith, 1998; Stylianides & Stylianides, 2008; Yabaş & Altun, 2020). This result highlights the importance of aligning curriculum development and textbook design with the goal of balancing procedural skills with in-depth conceptual understanding and critical thinking in mathematics education (Sianturi et al., 2021). For instance, research shows that the effectiveness of mathematics tasks varies depending on CDLs (Ayres, 2006; Estrella et al., 2020; Polat & Dede, 2023; Wakhata et al., 2023). Furthermore, Stein et al. (1996) provide compelling evidence that well-chosen and carefully implemented mathematics tasks can greatly support students' higher-order thinking. Incorporating more demanding tasks in textbooks would enable students to develop their analytical and critical thinking abilities, skills that are crucial for navigating complex mathematical problems in academic contexts and later in professional life (Boston & Smith, 2011). To ensure students' success, educators and curriculum designers should prioritize tasks that require higher-level thinking skills over those that merely promote lower-level thinking skills (Jackson et al., 2013; Parrish & Bryd, 2022).

Conversely, the absence of High-M level tasks in certain units of some textbooks indicates a focus on knowledge transmission and procedural learning, with little attention to complex, non-algorithmic thinking or deep conceptual exploration. This shortfall could hinder students' capacity to fully understand and apply mathematical concepts in new and unfamiliar contexts. Mathematics tasks that encourage critical thinking, problem-solving, establishing relationships between concepts, and drawing inferences are key to creating effective learning environments. These tasks foster the use of higher-order thinking skills, which are fundamental to students' long-term success in mathematics (Barnett et al., 2024; Hsu, 2013; Özkale & Aprea, 2023). Therefore, this study identifies a critical area for improvement in the design of mathematics textbooks, particularly in the inclusion of more cognitively demanding tasks.

In addition, the fact that the CDLs of mathematics tasks in different textbooks differ according to classes and books reveals the importance of organizing educational materials to cover a more balanced spectrum of cognitive demands. Considering that a significant amount of time in mathematics classes is dedicated to performing mathematics tasks (Roth & Givvin, 2008), it may be argued that improving teaching materials in this manner can provide a more equitable and inclusive learning environment for all students (Hadar & Ruby, 2019). Consequently, it is necessary to reassess and reorganize the cognitive levels of mathematics tasks in textbooks to promote high-level cognitive demands (Yabaş &Altun, 2020). Education policies and textbook development processes should be updated to support students' cognitive development and enhance their readiness for future challenges. This approach will cultivate an educational atmosphere that will deepen students' mathematical understanding and more effectively equip them for their future academic and professional lives (Hadar & Ruby, 2019).

The study's limitation lies in the exclusive examination of end-unit questions from eight middle school mathematics textbooks.

Conclusion and Recommendations

This research has carefully examined the CDLs of mathematics tasks in middle school mathematics textbooks currently used in Türkiye, uncovering a prevalent focus on low-level cognitive demands, notably within the Low-P category. This trend indicates that most tasks prompt students toward rote memorization and algorithmic procedures, rather than fostering a deep understanding of mathematical concepts. The scarcity of tasks that require high-level cognitive engagement, particularly those demanding complex mathematical reasoning or problem-solving, suggests a significant gap in textbook design.

The absence of high-level cognitive tasks limits students' opportunities to engage in substantial mathematical thinking. Current findings suggest that textbooks may not fully align with educational goals that emphasize the development of comprehensive cognitive skills, including critical thinking and problem-solving. To enhance the educational impact of these materials, it is crucial for curriculum developers and textbook authors to incorporate a broader range of cognitive demands. Ensuring a balance between procedural skills and deep conceptual understanding will better prepare students to meet academic standards and address real-world challenges.

Given the study's focus was limited to end-unit questions from a selection of textbooks, future investigations should broaden the scope to include a complete analysis of all tasks within these textbooks. Such comprehensive studies could provide a more detailed understanding of the cognitive demands presented by educational materials and their impact on student learning and achievement.

In summary, while this study highlights critical areas for improvement in textbook design and curriculum development, it also points to the need for continuous refinement of educational materials and practices. By adapting teaching resources to foster higher-order thinking skills, educators can better equip students for the complexities of modern academic and professional environments.

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