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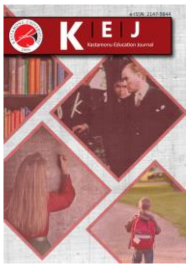

| Research Article / Araştırma Makalesi |

Evaluation of Questions in Middle School Mathematics Textbooks in Terms of Problem Solving Strategies

Ortaokul Matematik Ders Kitaplarında Yer Alan Soruların Problem Çözme Stratejileri Açısından Değerlendirilmesi

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Keywords

1. Problem solving
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Abstract

Purpose: This study aims to analyze solved problems in mathematics textbooks, focusing on both general and specific problem-solving strategies. By conducting a detailed analysis of each general strategy, the study seeks to provide a comprehensive evaluation of the problem-solving approaches presented in the textbooks.

Design/Methodology/Approach: The document analysis method was utilized in this study. Solved problems from the mathematics textbooks published by the Ministry of National Education (MoNE) for 5th, 6th, 7th, and 8th grades during the 2023-2024 academic year were examined. Data were collected using the "Solved Problems Checklist" and "Problem-Solving Strategies Determination Form" developed by Hatay (2020). A qualitative descriptive analysis method was employed to analyze the data, with percentage and frequency values calculated to present the findings.

Findings: The analysis revealed that the stages of planning and implementing a solution plan were prominently featured in the middle school mathematics textbooks. Specifically, the initial stage of understanding the problem often included visual aids such as figures, diagrams, tables, and pictures. In the planning phase, the predominant solutions involved discussions of mathematical operations.

Highlights: The study's findings indicate that while problem-solving strategies are generally emphasized in mathematics education, certain steps, such as solution evaluation, are given greater focus. Additionally, the research highlights a significant gap in the inclusion of the problem-posing stage, the final step of general problem-solving strategies, in the analyzed mathematics textbooks.

Öz

Çalışmanın amacı: Bu çalışma, matematik ders kitaplarındaki çözülmüş problemleri hem genel hem de özel stratejileri inceleyerek analiz etmeyi amaçlamaktadır. Çalışma, her bir genel stratejinin ayrıntılı bir analizini yaparak ders kitaplarında sunulan problem çözme yaklaşımlarının kapsamlı bir değerlendirmesini sağlamayı öngörmektedir.

Materyal ve Yöntem: Bu çalışmada doküman analizi yöntemi kullanılmıştır. Çalışmada Milli Eğitim Bakanlığı (MEB) tarafından 2023-2024 eğitim-öğretim yılında ortaokul 5, 6, 7 ve 8. sınıflar için yayımlanan matematik ders kitaplarında yer alan çözümlü problemler incelenmiştir. Verilerin toplanmasında Hatay'ın (2020) çalışmasında yer alan "Çözümlü Sorular Kontrol Listesi" ve "Problem Çözme Stratejileri Belirleme Formu"ndan yararlanılmıştır. Araştırmada nitel bir yaklaşım olan betimsel analiz yöntemi kullanılmıştır. Bulgulara ilişkin yüzde ve frekans değerleri hesaplanmıştır.

Bulgular: Yapılan analizler, plan yapma ve planı uygulama adımlarına ortaokul matematik ders kitaplarında belirgin bir şekilde yer verildiğini ortaya çıkarmıştır. Çözülen problemler genel stratejiler açısından incelendiğinde, problemi anlama basamağında çoğunlukla şekil, diyagram, tablo ve resimlerden yararlanıldığı görülmüştür. Planlama aşamasında ise çözümlerin ağırlıklı olarak matematiksel işlemler etrafındaki tartışmaları içerdiği görülmüştür.

Önemli Vurgular: Bu çalışmanın bulguları, matematik eğitiminde genellikle problem çözme stratejilerine vurgu yapılırken, çözümü değerlendirme gibi belirli adımlara daha fazla odaklanıldığını ortaya koymaktadır. Araştırma, matematik ders kitaplarında genel problem çözme stratejilerinin son aşaması olan problem kurma adımında dikkate değer bir boşluğa dikkat çekmektedir.

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INTRODUCTION

To live independently, individuals must possess a high level of problem-solving skills (Soylu & Pala, 2018). In daily life, we frequently encounter a wide range of problems—ranging from relatively simple issues like gum sticking to our shoes to more complex challenges such as inflation crises or geopolitical conflicts—that require effective solutions. Even a question posed by a friend or a task assigned by a teacher can present a challenge (Gelbal, 1991). In this context, a problem is defined as a situation that an individual encounters for the first time, desires to solve, but whose solution is not immediately apparent (Özdişçi & Katrancı, 2020). Problem-solving skill refers to the ability to think critically about a problem, decide on appropriate actions, utilize available resources, and reach a solution. It is believed that students who are capable of independently solving similar problems in daily life will become more autonomous individuals (Çolpan Kuru, 2021). Thus, problem-solving can be regarded as a vital component of life skills. In this context, problem-solving represents a critical thinking process essential for addressing various challenges (Özsoy, 2014). As a result, it has become a central focus in many academic disciplines, especially in mathematics education. The importance of problem-solving is extensively emphasized in both international (Ontario Ministry of Education, 2005; UK Department for Education, 2013; Toh et al., 2019) and national mathematics curricula (MoNE, 2013; MoNE, 2018), highlighting its significance. It is expected that this focus on problem-solving will be reflected in textbooks. As Bayrak (2022) observes, mathematics students are expected to engage extensively with problems presented by their textbooks and instructors. However, research suggests that many students struggle with this aspect of learning (Garderen, 2006; Kusumadewi & Retnawati, 2020). Improving problem-solving skills necessitates deep engagement with textbooks, particularly with the methods and strategies for problem-solving they present (Jäder et al., 2020). Consequently, the quality of a textbook can often be evaluated based on the presence and quality of problems that foster problem-solving strategies. This study provides a comprehensive analysis of the solved problems and problem-solving strategies in mathematics textbooks to assess their effectiveness and instructional value.

Theoretical Framework

Problem Solving Strategies

Students often encounter difficulties with mathematical problems due to various factors, such as a reluctance to engage with lengthy problem texts, which undermines their ability to effectively address mathematical challenges (Phonapichat et al., 2014). Additionally, students frequently struggle due to either a lack of comprehension of the problem itself or an inability to select appropriate strategies for resolution (Sulistyani et al., 2021). As Posamentier and Krulik (1998) emphasize, problem-solving not only assesses students' mathematical abilities but also offers essential opportunities to apply these skills in practical, real-world contexts.

A seminal framework in this field is Polya's four-stage model (1973), which outlines a systematic approach to tackling mathematical problems. This model consists of four stages: understanding the problem, devising a plan (translate), carrying out the plan (solve), and evaluating and interpreting the results (look back). In addition to Polya's model, problem posing has emerged as a key component of developing problem-solving skills, as it effectively bridges mathematical concepts with real-world applications (El Sayed, 2002). Gonzales (1994) suggests that problem posing should be added as the final stage in the problem-solving process, further enhancing the practical application of mathematical concepts.

Moreover, a wide range of problem-solving strategies has been identified, reflecting a more nuanced understanding of how these strategies can be effectively implemented in educational settings. Intaros et al. (2014) note that since students have different ways of thinking, problem-solving strategies can be utilized in various forms. Posamentier and Krulik (1998) have outlined several key strategies, including working backwards, identifying patterns, adopting multiple perspectives, solving simpler or analogous problems, considering extreme cases, using visual representations, approximating through forecasting and testing, considering all possibilities, organizing data, and applying logical reasoning. Recent research by Koç Koca and Gürbüz (2021) indicates that these strategies are not only diverse but are also evolving in complexity. This study aims to investigate how both general and specific problem-solving strategies, such as working backwards and pattern recognition, are represented and emphasized in mathematics textbooks, assessing their potential to enhance students' problem-solving skills.

Problems used in Textbooks

The use of mathematics textbooks in educational settings is crucial as it reflects the integration of mathematical culture into the learning environment through content and instructional strategies (Galiç et al., 2024). Therefore, a comprehensive analysis of mathematics textbooks reveals how teachers utilize these resources and what factors shape their usage (Rahimah & Visnovska, 2021; Sevimli et al., 2022). Furthermore, the analysis helps identify the relationship between updated mathematics curricula and the textbooks that support them (O'Keeffe, 2014). Since mathematics textbooks significantly influence students' learning experiences and opportunities (Törnroos, 2005), it is important to critically assess their content.

However, these textbooks often feature an overabundance of repetitive, routine problems that primarily require basic operations for their solutions (Marchis, 2012; Kolovou et al., 2011), commonly referred to as routine or ordinary problems (Bayrak, 2022). Moreover, tasks that can be classified as authentic mathematical problems are often scarce. When such problems do appear, they are typically found at the end of chapters and are presented in a purely mathematical context, limiting their application to real-world scenarios (Brehmer et al., 2016). Research exploring the perceptions of teachers and students regarding mathematics textbooks in Türkiye has revealed significant shortcomings (Arslan & Özpınar, 2009). For instance, Karekelleoğlu

(2007) concluded that the problems in mathematics textbooks were not appropriately leveled for students and were disconnected from their daily lives and needs. Similarly, Kazancı Dede (2020), in her study "Content Analysis of 11th Grade Mathematics Textbook and Determination of Teachers' Opinions", found that the evaluation sections in textbooks predominantly assess procedural knowledge and formula application rather than fostering a deeper, more comprehensive understanding of mathematics. Additionally, Dayak (1998) reported that students found textbooks cluttered with unnecessary information and excessive detail, while teachers felt that textbooks failed to enhance students' problem-solving skills. Furthermore, Deringöl (2020), in her analysis of problem-posing in mathematics textbooks, found that certain grade levels did not include problem-posing exercises at all. Despite these critiques, textbooks are recognized as having a significant impact on students' mathematical achievement (Mullis et al., 2012).

Research on mathematics textbooks, both nationally and internationally, often focuses on categorizing problems according to criteria such as routine versus non-routine and easy versus difficult (Jäder et al., 2020). In the national literature, substantial attention has been devoted to analyzing the problem-solving strategies used in mathematics textbooks (Çelik, 2019; Kıral-Demir & Katrancı, 2023; Hatay & Cihangir, 2021). Diverging from other studies, Fan and Zhu (2007) examined both general and specific strategies. In their comparative analysis of middle school mathematics textbooks from China, Singapore, and the USA, they applied Polya's four-stage problem-solving model to investigate general strategies, identifying 17 specific problem-solving strategies, such as 'role-playing', 'seeking patterns', and 'working backwards'. Further literature review reveals that discussions on problem-solving strategies in mathematics textbooks generally emphasize specific strategies. For instance, Çelik (2019) analyzed 10th grade mathematics textbooks and identified prevalent strategies such as the "equality or inequality writing strategy", "reasoning strategy", and "diagramming strategy". Şişçi (2023), in her analysis of middle school mathematics textbooks, found that strategies like setting equations, reasoning, and drawing figures were the most frequently used. In contrast, strategies such as simplifying the problem and working backwards were less common. Moreover, problems that allow for multiple problem-solving strategies were rarely included in these textbooks.

In the national literature, numerous studies have focused on specific problem-solving strategies in mathematics textbooks. However, problem-solving should also be considered as a comprehensive approach, similar to Polya's (1973) four-stage problem-solving process. Furthermore, incorporating problem-posing as a fifth stage could enhance students' learning experiences within the mathematics curriculum (MoNE, 2018). This study proposes that Polya's process be expanded to include problem-posing in the mathematics textbooks under examination. In addition, textbooks should not only elaborate on Polya's model but also extensively discuss specific problem-solving strategies. By analyzing textbook problems with attention to both general and specific problem-solving strategies, this study aims to provide insights into the effectiveness of these strategies. Unlike other studies, Hatay and Cihangir (2021) analyzed the solved problems in the 7th grade mathematics textbook using both general and specific strategies outlined by Polya. However, no comprehensive evaluation of mathematics textbooks across all grade levels in Turkey has been conducted that considers both perspectives.

This study hypothesizes that a thorough analysis of problem-solving strategies across all grade levels will provide essential guidance for mathematics teachers, the primary users of these textbooks. Kıral-Demir and Katrancı (2023) analyzed the solved problems in mathematics textbooks in the context of general strategies, with their distribution according to units and topics. However, this study will also analyze the steps within the problem-solving strategies, providing a more comprehensive understanding of how these strategies are implemented in mathematics textbooks. Since textbook selection plays a crucial role in shaping teaching methods and learning outcomes, determining both pedagogical approaches and student engagement (Reys et al., 2004), it is critical that mathematics textbooks include problems that enhance students' problem-solving skills. Şişçi (2023) underscores the importance of students being aware of various problem-solving methods and recognizing that problems can often be solved in multiple ways. Similarly, Xin (2007) found a significant correlation between the tasks in mathematics textbooks and students' academic performance, highlighting the impact of well-designed problems.

In conclusion, this study aims to analyze the solved problems in mathematics textbooks, examining both general and specific strategies. By conducting a detailed analysis of each general strategy, this study anticipates providing a comprehensive evaluation of the problem-solving approaches presented in these textbooks.

METHOD

Research Design

The objective of this study is to examine the problems in the mathematics textbooks used in middle schools in the 2023-2024 academic year in terms of the inclusion of problem-solving steps and problem-solving strategies. The document analysis method was employed in this study. Document analysis, also known as documentary scanning, is a method of examining and coding existing records and documents relevant to the study (Çepni, 2014).

Data Collection Tools

The aim of this study was to analyze the solved problems in mathematics textbooks published by the Ministry of National Education (MoNE) for the 5th, 6th, 7th, and 8th grades of middle school in the 2023-2024 academic year. Consulted sources included works by Korkmaz et al. (2023), Çağlayan et al. (2021), Külköylüoğlu et al. (2023), and Böge and Akıllı (2021). The textbooks containing solved problems were officially designated as primary resources by the MoNE Board of Education and

Discipline, with decisions dated 9 May 2022 (numbered 36 for 5th and 7th grades) and 28 May 2018 (numbered 78 for 6th and 8th grades). To select the textbooks and problems for analysis, opinions from three academicians who are expert in mathematics education were sought. Following their guidance, a total of 1,010 problems with solutions were examined, distributed as follows: 306 in the 5th grade, 159 in the 6th grade, 246 in the 7th grade, and 299 in the 8th grade mathematics textbooks.

The study assessed solved problems in textbooks to determine if they incorporated Polya's (1997) problem-solving steps, including problem posing. For this analysis, the "Solved Problems Checklist" and the "Problem Solving Strategies Determination Form" from Hatay's (2020) study were utilized. The Checklist includes 21 items that evaluate various aspects of problem-solving, such as understanding the problem, devising a plan, carrying out the plan, and look back and reflect. Notably, it also assesses the problem posing step. One specific item from Hatay's study—'constructing another problem appropriate to the data in the problem'—originally linked to the evaluation step, was treated as a distinct element associated with problem construction in this analysis.

The checklist consists of several items categorized by the stages of problem-solving. For understanding the problem, seven items (items 1-7) address criteria such as explaining unknown words, clarifying what is given and required, dividing problems into sub-problems, utilizing mathematical materials and technology, and employing figures, diagrams, tables, and pictures to elucidate learned concepts. Four items (items 8-11) pertain to the formulation of a plan and include criteria for mentioning mathematical and logical operations, hypothesizing, and determining strategies. The implementation of the plan is covered by three items (items 12-14), which involve the use of strategies, testing hypotheses, and solving problems based on set criteria. Six items (items 15-20) evaluate the solution, focusing on demonstrating alternative solution approaches, verifying mathematical and logical operations, making comments, producing formulas, generalizing solutions, and linking hypotheses with results. Furthermore, one item (item 1) specifically addresses the criteria related to problem posing. The form developed to identify problem-solving strategies includes ten distinct techniques, as outlined by Hatay (2020): systematic list making, drawing figures and diagrams, finding relations, simplifying the problem, working backwards, employing estimation and control strategies, establishing equations and inequalities, making tables, reasoning, and utilizing animation strategies.

Research Procedure

To analyze the solved problems, each criterion listed on the 'Solved Problems Checklist' and the 'Problem Solving Strategies Identification Form' was coded with a "1" if present during the solution stage of the problem, and "0" if absent. For a solved problem to be considered as including a specific problem-solving step, at least one of the criteria associated with that step on the Checklist must be met. If any criterion under a specific problem-solving step is identified—even if several other items could also represent that step—it was concluded that the examined solution encompasses that particular step. Data were systematically recorded in a Microsoft Office Excel 2019 worksheet, with separate tabs for each resource analyzed across different grade levels. Within these tabs, individual problems were sequentially numbered (P1, P2, ..., etc.), with each row containing data pertinent to a specific problem. In the study, the items on the Solved Problems Checklist and Problem Solving Strategies Identification Form were succinctly named and listed in the columns in the same order as they appeared on the respective forms. The Checklist is divided into sections, which facilitated the naming convention in the Excel worksheet:

• Understanding the Problem (PA): Items 1-7 were labeled as A1, A2, ..., A7.

• Devising a Plan (PD): Items 8-11 were labeled as B8, B9, B10, B11.

• Carrying out the Plan (PC) and Evaluating the Solution (ES): Items 12-14 were labeled as C12, C13, C14, and items 15-20 were labeled as C15, C16, ..., C20.

• Problem Posing (PP): This step was uniquely labeled as PP and coded with a 0 if absent, 1 if present in a structured format, 2 if semi-structured, and 3 if unstructured (free-form).

The Problem Solving Strategies on the Identification Form were labeled as ST1, ST2, ..., ST10. Additional columns were added to the Excel worksheet: "Number of Steps" to record the count of problem-solving steps identified in each solution, and "Page No". to note the textbook page on which each problem was found. An illustrative example of how the problems were analyzed is presented in Figure 1.

Cacabey Madrasah, a work of the Anatolian Seljuk Period completed in Kırşehir in 1272, was an astronomy center where astronomy research was conducted at the time. The reliefs used in its architecture symbolize the shape of the world, while the spheres symbolize the Sun and the Moon. The columns resembling missiles and the observation tower used as a minaret today are striking. In addition, the traces of the 10th planet of the solar system, which scientists announced to the world in 2005, took their place on the columns in the madrasah approximately 750 years ago.

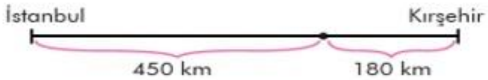
A group of students who wanted to see Cacabey Madrasah set off from Istanbul to Kırşehir by car, covered 450 km in 300 minutes and then took a break. Continuing at the same speed after the break, this vehicle had 180 km left to reach its destination. Accordingly, let's find out how many hours it took the vehicle to cover the distance between Istanbul and Kırşehir.

Let's Understand the Problem

We know that this vehicle traveled 450 km in 300 minutes and has 180 km left to go. It is desired to find how many hours it will take to complete the distance between Istanbul and Kırşehir.

Let's Plan the Problem

Let's express our problem with a figure showing the distance between Istanbul and Kırşehir.



Let's Implement the Plan

Let's convert 300 minutes into hours. 300 ÷ 60 = 5 hours
Let's find how many km he travels in 1 hour. 450 ÷ 5 = 90 km
He travels the remaining 180 km in 180 ÷ 90 = 2 hours.
He travels the distance between two cities in 5 + 2 = 7 hours.

Let's Check the Solution

If the vehicle travels 90 km in 1 hour, it travels 90 · 7 = 630 km in 7 hours.
We find that the vehicle travels a total of 450 + 180 = 630 km and see that both results are equal.

You too, pose a problem about a situation with a similar application, solve the problem using the solution steps above and share it with your friends.

Understanding the Problem (PA):
- Cacabey Madrasah - Elucidated the rationale behind differing student expressions - **Elucidation of Ambiguous Terminology (A1)**
- Considering a vehicle that traveled 450 km in 300 minutes with 180 km remaining, it is deduced that the distance between Istanbul and Kırşehir is to be determined - **Elucidation of the Provided and Requested Information (A2).**

Devising a Plan (PD):
- The problem was visualized with a figure representing the distance between Istanbul and Kırşehir, which guided the strategic approach – **Determining of an Appropriate Strategy (B11)**

Carrying out the Plan (PC):
The plan involved converting 300 minutes into hours, calculating the distance km traveled per hour, determining the time needed to travel the remaining 180 km, and calculating the total travel time between the two cities - **Implementation of the Plan (C14).**

Evaluating the Solution(PS):
The solution's effectiveness was evaluated by verifying that the total distance calculated by multiplying the total time by speed per hour, and adding the distances given, matched the initial problem data. This step included **checking logical operations (C17).**

Problem Posing (PS)
A new problem was formulated based on a similar situation.

Problem Solving Strategies:
creating shapes and diagrams as part of the strategy - **Creation of Shapes and Diagrams (ST2).**

Stages of the Solution:
The solution comprised five stages: Understanding the Problem (PA), Devising a Plan (PD), Implementing the Plan (PC), Evaluating the Solution (ES), and Problem Posing (PP).

Figure 1. Example of a problem analysis with solution (Çağlayan et al., 2021, p. 25).

Data Analysis

The study employed the descriptive analysis method, a qualitative approach aimed at presenting findings by organizing and summarizing data in a descriptive manner (Creswell, 2016). Data analysis was conducted using Microsoft Office 19 Excel. Frequency (f) and percentage (%) values were computed to assess the inclusion of items from the data collection tool in the solved problems studied. The subsequent section presents the results in tabular format.

In evaluating the solved problems within the 5th, 6th, 7th, and 8th grade mathematics textbooks published by the Ministry of National Education (MoNE) for the presence of problem-solving steps and strategies, ensuring the validity and reliability of the study was paramount. To uphold validity, the perspectives of three experts in elementary mathematics education were solicited regarding the items in both the problem-solving checklist and the problem-solving strategies identification form. These experts assessed each item for clarity, comprehensibility, and relevance to the respective problem-solving step. Additionally, they were encouraged to highlight any concerns they deemed necessary beyond these evaluations. Following this thorough review, a consensus among the experts confirmed the suitability of the data collection instruments for the study's objectives.

Furthermore, to maintain study validity, the presentation of data analysis results was executed with clarity and precision. This involved transparently elucidating the methodologies employed to derive these results and providing detailed descriptions of the data, accompanied by direct examples of the findings. Through these measures, the study aimed to uphold the integrity and trustworthiness of its outcomes.

In order to ensure the reliability of the study, the solved problems were analysed by two different researchers and coded independently. In order to determine the agreement between the coders, the reliability formula proposed by Miles and Huberman (1994) (Reliability: [(Agreement)/(Agreement+Disagreement)x100]) was employed, along with the Cohen's Kappa Coefficient. The Kappa value calculated for the coding reliability of the study was 0.86. The value calculated with the reliability formula proposed by Miles and Huberman (1994) is 89%. A Kappa value between 0.80 and 1 is indicative of a high degree of agreement between coders, while a value of at least 80% according to the Miles and Huberman (1994) formula is indicative of achieved coding reliability (Cohen, 1960; Miles & Huberman, 1994). The results of the reliability analysis indicate that the evaluations of the solved problems are reliable. In instances where there was a discrepancy between the coders' evaluations, the coders convened to discuss the rationale behind these differing assessments and ultimately reached a consensus. An illustration of the discrepancies in the assessments of the independent coders is presented in Figures 2 and 3.

Let's find how much money Mr. Ihsan, who wants to buy a refrigerator with a price of 3000 liras, has to pay each month if she makes the payment in cash or in 2, 3, 4, or 5 installments.

The amount of money Mr. İhsan will pay each month can be expressed as $\frac{3000}{x}$.

Algebraic Expression	Variable (Number of Installments)	Money to be Paid Every Month
	For x = 1	$\frac{3000}{x} = \frac{3000}{1} = 3000\ liras$
	For x = 2	$\frac{3000}{x} = \frac{3000}{2} = 1500\ liras$
$\frac{3000}{x}$	For x = 3	$\frac{3000}{x} = \frac{3000}{3} = 1000\ liras$
	For x = 4	$\frac{3000}{x} = \frac{3000}{4} = 750\ liras$
	For x = 5	$\frac{3000}{x} = \frac{3000}{5} = 600\ liras$

Figure 2. An example of a problem-1 that has been solved and evaluated differently by two independent coders (Çağlayan et al., 2021, p. 133).

In the case presented, one coder labeled the strategy used in the problem solution from the 6th-grade textbook, as shown in Figure 2, as "making a table (ST8)", while the other coder categorized it as "finding relations (ST2)". As a result of this disparity, it was concluded that the employed strategy was "finding relations (ST2)".

Aysun, who wants to collect a napkin collection, found 11 napkins for her first week's collection and added 5 napkins to her collection each week. Let's express the relationship between the number of napkins and the number of weeks as an algebraic expression.

SOLUTION: Let's notice that the difference between consecutive weeks is 5. Let's create a table showing the relationship between the number of weeks and the number of napkins.

Week	**1**	**2**	**3**	**4**	**5**	**6**	**...**	**n**
Total Number of Napkins	11	16	21	26	31	36	...	
Relationship Between Number of Napkins and Number of Steps	6 + 5 . **1**	6 + 5 . **2**	6 + 5 . **3**	6 + 5 . **4**	6 + 5 . **5**	6 + 5 . **6**	...	6 + 5 . **n**

Accordingly, the rule of the pattern is found as "6 + 5 · n" or "5 · n + 6".

Figure 3. An illustrative example-2 of a problem that has been solved and evaluated by two independent coders (Külköylüoğlu et al., 2023, p. 102)

As depicted in Figure 2, the coding of the strategy employed in the solution of the problem presented in the 7th-grade textbook, as shown in Figure 3, resulted in two distinct outcomes. One coder labeled the strategy as "making a table (ST8)", while the other coder categorized it as "finding relations (ST2)". Following discussions, the two coders reached a consensus that the strategy utilized was "finding relations (ST2)".

FINDINGS

General Strategies for Problem Solving

The general strategies addressed in mathematics textbooks include Polya's (1973) problem solving steps and Gonzales' (1994) problem posing step. Findings related to problem solving steps are presented in Table 1.

Table 1. According to problem solving steps

	5. grade		6. grade		7. grade		8. grade		Total	
Understanding the Problem	263	26%	155	16%	150	15%	190	19%	758	75%
Devising a Plan	255	25%	151	15%	183	18%	241	24%	830	82%
Carrying out a Plan	306	30%	149	14%	245	24%	299	30%	999	99%
Evaluation Solution	142	14%	118	12%	118	12%	148	15%	526	52%
Problem Posing	4	1%	4	1%	0	0%	0	0%	8	1%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

Upon analysis of the values presented in Table 1, it becomes evident that the step of applying the plan is consistently included in the solved problems presented in the textbooks at all grade levels. However, it is notable that the step of constructing a problem is given minimal attention across all grade levels. The findings obtained as a result of the analysis, according to the behaviours related to the problem comprehension step, are presented in Table 2.

Table 2. According to behavioural patterns observed during the understanding stage of the problem

	5. grade		6. grade		7. grade		8. grade		Total	
Explaining Unknown Words	13	1%	39	4%	0	0%	36	4%	88	9%
Explaining what is given and what is required	175	17%	120	12%	62	6%	54	5%	411	41%
Dividing Problems into Sub-Problems	13	1%	102	10%	2	0%	1	0%	118	12%
Using Mathematical Materials	17	2%	79	8%	13	1%	49	5%	158	16%
Using Technology	11	1%	53	5%	0	0%	21	2%	85	8%
Using Figure, Diagram, Table and Picture	176	17%	115	11%	135	13%	158	16%	584	58%
Explaining Learned Concepts	24	2%	80	8%	3	0%	10	1%	117	12%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

When Table 2 is examined, it is seen that the most frequently identified behaviours related to the step of understanding the problem in the problems examined in the 5th grade textbook are 'explaining what is given and what is required' and 'using figures, diagrams, tables and pictures' with 17%. Similarly, in the 6th grade textbook, the most frequently identified behaviour was 'explaining what is given and what is required' with 12%, and in the 7th and 8th grade textbooks, the most frequently identified behaviour related to the step of understanding the problem was 'using figures, diagrams, tables and pictures' with 13% and 16%, respectively. The results of the analysis, presented in Table 3, demonstrate the frequency with which students engage in behaviours related to the devising step.

Table 3. According to the behaviours related to the devising a plan step

	5. grade		6. grade		7. grade		8. grade		Total	
Talking about Mathematical Operations	150	15%	145	14%	130	13%	152	15%	577	57%
Mentioning Logical Operations	125	12%	34	3%	39	4%	47	5%	245	24%
Hypothesis Formulation	18	2%	40	4%	3	0%	64	6%	125	12%
Strategy Identification	184	18%	136	13%	81	8%	130	13%	531	53%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

When the values in Table 3 are examined, it is noteworthy that the most common behaviour related to the devising a plan step in the solved problems examined in the books at all grade levels is ‘mentioning logical operations’. ‘Identification a strategy’ was the second most common behaviour in the problems examined at all grade levels. An example of the behaviour of ‘mentioning mathematical operations’ in the plan making step is presented in Figure 4.

In a province, a bus providing urban transportation, which initially had no passengers, was boarded by 22 passengers at the first stop and the bus departed. The number of passengers boarding and getting off the bus at the stops is given in the table below.

Table: Number of Passengers Getting on and off at Stops

Stops	Number of Passengers Getting off	Number of Passengers Getting on
Stop 2	8	11
Stop 3	12	5
Stop 4	3	7
Stop 5	13	1

According to the information in the table, let's find the number of passengers on the bus when it departs from the 5th stop.

SOLUTION: Using addition and subtraction operations with integers, let's find the total number of passengers getting on and off the bus at the stops separately.

The total number of passengers getting off the bus is 8 + 12 + 3 + 13 = 36,

The total number of passengers getting on the bus is 11 + 5 + 7 + 1 = 24.

In the last case, when the bus departs from the 5th stop, the number of passengers on the bus is 22 + (-36) + 24 = 10.

Figure 4. An example problem with solution for the behaviour of ‘talking about mathematical operations’ in the devising a plan step (Külköylüoğlu et al., 2023, p. 34)

The findings obtained as a result of the analysis according to the behaviours related to the carrying a plan step are presented in Table 4.

Table 4. According to the behaviours related to the step of carrying a plan

	5. grade		6. grade		7. grade		8. grade		Total	
Using a Strategy	209	21%	141	14%	140	14%	138	14%	628	62%
Testing Hypothesis	7	1%	47	5%	5	0%	8	1%	67	7%
Solving the Problem	306	30%	155	15%	245	24%	297	29%	1003	99%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

When the values in Table 4 are examined, it is noteworthy that the most common behaviour related to the step of implementing the plan in the solved problems examined in the books at all grade levels is ‘solving the problem’. It is seen that ‘using strategy’ behaviour is the second most common behaviour in the problems examined at all grade levels. The findings obtained as a result of the analysis according to the behaviours related to the step of evaluating the solution are presented in Table 5.

Table 5. According to the behaviours related to the step of evaluating the solution

	5. grade		6. grade		7. grade		8. grade		Total	
Showing Various Solutions	15	1%	35	3%	26	3%	29	3%	105	10%
Verifying the Mathematical Operation	6	1%	59	6%	8	1%	11	1%	84	8%
Verifying Logical Operation	21	2%	76	8%	5	0%	53	5%	155	15%
Making a comment	107	11%	88	9%	98	10%	102	10%	395	39%
Formula generation and generalisation	9	1%	39	4%	14	1%	7	1%	69	7%
Associating the hypothesis with the result	9	1%	21	2%	1	0%	0	0%	31	3%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

When Table 5 is examined, it becomes apparent that across all grade levels, the most commonly identified behavior related to the step of evaluating the solution is ‘commenting’. In the 5th, 6th, and 8th grade textbooks, ‘commenting’ is followed by ‘verifying the logical operation’. Conversely, in the problems assessed in the 7th grade textbook, ‘showing various solutions’ emerges as the second most prevalent behavior. Notably, ‘associating the hypothesis with the result’ is a rarely observed behavior in the solved problems across all grade levels.

In Table 3, concerning the step of devising a plan, it is evident that the behavior of ‘forming a hypothesis’ is seldom encountered. Considering this observation, it can be inferred that the scarcity of ‘testing the hypothesis’ behaviors in the carrying out a plan step and ‘associating the hypothesis with the result’ behaviors in the solution evaluation step naturally align with the low occurrence of ‘forming a hypothesis’ behaviors in the planning stage. The findings derived from the analysis regarding behaviors associated with the problem-posing step are detailed in Table 6.

Table 6. According to the behaviours related to the problem posing step

	5. grade		6. grade		7. grade		8. grade		Total	
Structured	4	0,004%	4	0,004%	0	0%	0	0%	8	0,008%
Semi-structured	0	0%	0	0%	0	0%	0	0%	0	0%
Unstructured	0	0%	0	0%	0	0%	0	0%	0	0%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

When Table 6 is examined, it is seen that in the solved problems examined in the textbooks at all grade levels, ‘structured’ problem-posing behaviour is preferred among the behaviours related to the problem-posing step, which is already quite rare. Semi-structured or free problem posing behaviours were not included. An example of ‘structured problem posing’ behaviour in the problem posing step is presented in Figure 5.

Let's set up a problem using the operations on the side and solve it.

$\frac{3}{16}+\frac{7}{16}$ $1-\frac{10}{16}$

SOLUTION:

We need to set up a problem where $\frac{3}{16}$ is added to $\frac{7}{16}$ and then $\frac{10}{16}$ is subtracted from 1.

We can pose a problem in the form of “Esma first read 3/16 and then 7/16 of a novel. What fraction of the total number of pages in the novel does Esma not read represent?”.

Let's solve this problem.

The number of pages read in the novel is $\frac{3}{16}+\frac{7}{16}=\frac{3+7}{16}=\frac{10}{16}$

The number of unread pages of the novel is $\underset{(16)}{\frac{1}{1}}-\frac{10}{16}=\frac{16}{16}-\frac{10}{16}=\frac{16-10}{16}=\frac{6}{16}=\frac{8}{3}$

❖ You pose another problem using the given operations.

Figure 5. A sample of solved problem for the behaviour of ‘structured problem posing’ in the problem posing step (Korkmaz et al., 2023, p. 128)

Specific Strategies for Problem Solving

The findings obtained as a result of the analysis according to the problem solving strategies used are presented in Table 7.

Table 7. According to problem solving strategies

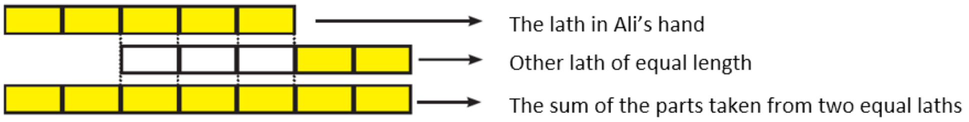
	5. grade		6. grade		7. grade		8. grade		Total	
Systematic list	4	0%	34	3%	3	0%	9	1%	50	5%
Figure and diagram	99	10%	80	8%	89	9%	88	9%	356	35%
Finding a relation	5	0%	26	3%	12	1%	4	0%	47	5%
Simplifying the problem	4	0%	98	10%	9	1%	1	0%	112	11%
Working backwards	2	0%	24	2%	0	0%	2	0%	28	3%
Forecasting and control	31	3%	50	5%	0	0%	3	0%	84	8%
Establishing equations and inequalities	0	0%	25	2%	42	4%	28	3%	95	9%
Making a table	21	2%	15	1%	4	0%	16	2%	56	6%
Reasoning	169	17%	23	2%	32	3%	0	0%	224	22%
Animation	0	0%	13	1%	8	1%	4	0%	25	2%

** Percentage values were calculated over a total of 1010 solved problems analysed in the study.*

According to Table 7, it is seen that the most commonly used strategy in the solved problems examined in the 5th grade textbook is ‘reasoning’ with 17%, the most commonly used strategy in the solved problems examined in the 6th grade textbook is ‘simplifying the problem’ with 10%, and the most commonly used strategy in the solved problems examined in the 7th and 8th grade textbooks is ‘figure and diagram’ with 9%. In general, it is noteworthy that the most commonly used strategy in the 1010 solved problems analysed in the study is the ‘figure and diagram’ strategy with 35%. It is seen that ‘animation’ and ‘working backwards’ strategies are less preferred with 2% and 3% respectively. Examples of solved problems in which the ‘figure and diagram’ strategy and the ‘animation’ strategy were used are presented in Figure 6 and Figure 7, respectively.

If the sum of a lath in Ali's hand and $\frac{2}{5}$ of another lath of equal length is 140 cm, let's find the length of the lath in Ali's hand in centimeters.

SOLUTION: Let's take a lath consisting of five pieces.



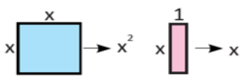
A total of 7 equal pieces are obtained. Since the total length is 140 cm, the length of each equal unit is 140 ÷ 7 = 20 centimeters.

Since the lath consists of 5 equal units, the length of the lath is found as 20 · 5 = 100 cm = 1 meter.

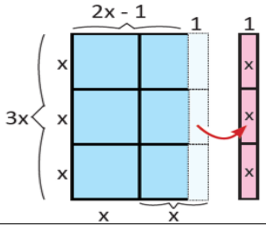
Figure 6. A sample solved problem using the ‘figure and diagram’ strategy (Külköylüoğlu et al., 2023, p. 86)

Let's do the multiplication of 3x(2x - 1).

Let's cut the colored papers with scissors and create algebra tiles as below.



Method 1: We can perform the operation 3x (2x - 1) using modeling for x > 1. Let's create an algebra tile with one side length 3x and the other side length 2x.



Let's cut 3 algebra tiles with one side length 1 and the other side length x from the created algebra tile with scissors as shown. The area of the remaining rectangular region is 3x(2x - 1) = 6x² - 3x.

Method 2: Let's do the multiplication by using the distributive property.

$$3x(2x - 1) = 3x \cdot 2x + 3x \cdot (-1)$$
$$= 6x^2 - 3x$$

Figure 7. A sample solved problem using the ‘animation’ strategy (Böge & Akıllı, 2021, p. 91)

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study, solved problems from mathematics textbooks across various grade levels were analyzed to identify the general and specific strategies employed. The analysis revealed that the steps of planning and implementing a plan were prominently featured in middle school mathematics textbooks for the 2023-2024 academic year. This finding aligns with the research of Hatay and Cihangir (2021) on seventh-grade mathematics textbooks. Additionally, Kıral-Demir and Katrancı's (2023) investigation of middle school textbooks identified significant gaps in different phases of the problem-solving process. Notably, the stages of understanding the problem and verifying the solution's accuracy were often overlooked, while the emphasis on the planning stage (devising a plan) varied by grade level. These results imply that the frequent inclusion of steps such as devising and carrying out a plan in the analyzed problems may indicate a predominance of routine problems in the textbooks. However, Arslan and Altun (2007) have noted that non-routine problems, which more closely resemble real-life situations, tend to engage students more effectively. Furthermore, Yıldız and Ev Çimen (2017) found that the number and diversity of problem-solving activities in mathematics textbooks were limited, suggesting that textbooks do not thoroughly incorporate a broad range of problem-solving strategies. These findings underscore the need for mathematics textbooks to be structured in a way that fosters a comprehensive set of problem-solving skills among students.

When analyzing the solved problems within mathematics textbooks in terms of general strategies, it was observed that the initial stage of understanding the problem often employed figures, diagrams, tables, and pictures. Conversely, in the planning phase, solutions predominantly involved discussions around mathematical operations, with solutions based on hypothesizing being notably fewer. This pattern persisted in the implementation phase, where hypothesizing remained minimal, while direct problem-solving approaches dominated. This trend suggests a scarcity of non-routine problems in textbooks, which aligns with findings from international research (Kolovou et al., 2011; Glasnovic Gracin, 2018). For example, a Romanian study highlighted a deficiency in non-routine problems that stimulate student creativity (Marchis, 2012). Both national (MoNE, 2013; MoNE, 2018) and international mathematics curricula (Ontario Ministry of Education, 2005; UK Department for Education, 2013; Toh et al., 2019) emphasize the importance of problem-solving. However, the prevalence of routine problems in textbooks across all examined grade levels raises concerns about the curricular implementation of problem-solving. Given that non-routine problems significantly enhance students' problem-solving skills, it is crucial to increase their presence in mathematics textbooks to better reflect educational goals and improve student outcomes.

The findings of this study reveal that while problem-solving strategies are generally emphasized in mathematics education, certain steps, such as solution evaluation, receive more focus. In contrast, problems requiring higher-level cognitive skills, such as formula generation and generalization, are less commonly included. This pattern is consistent with other detailed analyses of mathematics textbooks (Kul et al., 2018; Kıral-Demir & Katrancı, 2023). The insufficient presence of such high-level questions in Turkish mathematics textbooks may hinder students' ability to effectively tackle similar problems. Countries excelling in international assessment exams like TIMSS and PISA often include a higher number of problems requiring advanced cognitive skills in their textbooks. Singapore, for example, excels in mathematics education and extensively integrates problem-solving skills into its curriculum, encouraging students to engage with diverse problem types. Singapore's mathematics textbooks are designed to foster analytical thinking and versatile problem-solving strategies, enhancing students' mathematical reasoning abilities. Such preparation is crucial for students who will face various problem types in international assessments. Therefore, educational policies and textbooks in Türkiye should adopt more robust strategies to equip students with a broad spectrum of problem-solving skills. Enriching the content of mathematics textbooks is essential for improving student performance against both local and international benchmarks, which would, in turn, elevate national educational standards and boost Turkish students' competitiveness on the global stage.

The research highlights a notable gap in the problem-posing step, the final stage of general problem-solving strategies in mathematics textbooks. While structured problem-posing—where students generate problems based on a given situation or solution, as discussed by Stoyanova and Ellerton (1996)—is included, there is a significant absence of semi-structured or free problem-posing activities. Cai et al. (2015) define problem-posing as a cognitive process where students either create new problems or modify existing ones, indicating a dynamic approach to learning mathematics. Including free or semi-structured problem-posing activities in textbooks could significantly enhance students' ability to construct and engage with new problems, fostering deeper understanding and creativity. This approach is evident in countries that perform well in international assessments, where mathematics textbooks feature a broader variety of problem-posing activities compared to those in Türkiye, as noted by Çelik & Kul (2021). To better align with successful international practices and strengthen students' problem-solving capabilities, it is essential for educational policymakers and textbook publishers in Türkiye to integrate a broader range of problem-posing activities into the mathematics curriculum.

When analyzing specific problem-solving strategies, it was found that solved problems predominantly employed strategies such as using "figures and diagrams" and reasoning, whereas the strategy of working backwards was used the least frequently. This pattern is consistent with findings from other research. For instance, Şişçi (2023) reported that reasoning and diagramming were the most common strategies in both middle and high school mathematics textbooks. Additionally, Arslan (2023) observed that various problem-solving strategies were employed in sixth-grade mathematics textbooks, differing across learning domains. Türkmen (2022) specifically examined problem-solving strategies within the learning domain of numbers and operations in secondary school mathematics textbooks, noting a similar trend where diagramming was most prevalent and working backwards was least common. This consistency across various studies, including the present one examining textbooks across all grade levels, suggests that the dominance of certain strategies may be linked to the extensive focus on numbers and operations within the mathematics curriculum. These insights indicate a potential area for curriculum developers to consider diversifying the strategies taught and practiced in mathematics education to enhance students' problem-solving skills across a broader range of methods and contexts.

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Statements of publication ethics

I/We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The first and the second author jointly conceptualized the theoretical framework, determined the research questions, and designed the methodology. The first and second author conducted the processes of data collection, data analysis, and discussion of the results. The first author drafted the Turkish version of the manuscript, on which both authors collaborated. The third author revised the English version of the manuscript. Finally, the first author applied the article template and submitted the manuscript to the journal.

Ethics Committee Approval Information

We declare that this study is among the studies that do not require ethics committee approval. All the rules that were stated to be followed in the entire process from planning to implementation, data collection to data analysis of this research were followed. No actions were taken that were not in accordance with scientific research and publication ethics. No falsification was made on the collected data and this study was not sent for evaluation to any other academic publication environment.

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