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Original Article

Evaluation of the Mathematics Items on the Secondary Education Transition Examination (LGS) According to Process Standards *

Hilal Çelik [1], Zeynep Sonay Ay [2]

Abstract

The purpose of this study is to evaluate the central examination mathematics items applied within the scope of the Transition to the Secondary Education System by the process standards published by the National Council of Teachers of Mathematics. In this context, 40 mathematics items administered in 2020 and 2021 constituted the data for the research, and the possible solutions to these items were examined in detail according to the use of the process standards. When the items were analyzed regarding process standards, it was observed that nearly all of the standards were utilized in their possible solutions. In the solutions to the items from 2020, there was a predominant need for establishing connections between concepts and sub-concepts, while in 2021, a greater need was identified for associating concepts. In both years, formal language was more prevalent in communication, and quantitative representation was recognized as the predominant form of representation. When evaluating the items from both years, it was observed that they were well-designed to serve as good examples for predicting and measuring skills.

Keywords

Middle school-level mathematics
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Introduction

Each society aims to instill values, knowledge, skills, and behaviors in its individuals and organizes its education systems accordingly. Educational systems serve this purpose through curricula (Ministry of National Education [MoNE], 2018). The Mathematics Course Curriculum of 5th -8th grades also includes specific objectives that it aims to achieve.

The way these objectives are addressed within the framework of the MoNE published in 2009, 2013, and 2018 is as follows (MoNE, 2009; MoNE, 2013; MoNE, 2018). Students

- should be able to understand mathematical literacy and concepts, establish connections between them, and apply them in their daily lives.
- should acquire mathematical skills and knowledge that enable them to advance their education in mathematics or any other field.

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[1] Ministry of National Education, Türkiye, hilalcelik852@gmail.com

[2] Hacettepe University, Faculty of Education, Department of Mathematics and Science Education, Türkiye, sonayp@gmail.com

- should be able to reason in their unique way and express themselves while also being able to evaluate the mathematical reasoning of others throughout the problem-solving process
- should be capable of articulating their mathematical thoughts logically by using mathematical language correctly.
- should be able to represent concepts using different representations.
- should use the necessary skills to perform mathematical operations and predict results mentally.
- should be able to comprehend the relationships between objects.
- should be able to research, generate information, and utilize that knowledge.
- should establish connections between mathematics and art.
- should be able to develop self-confidence that they can do mathematics without prejudice by progressing with patient and planned steps.

When examining the book "Principles and Standards for School Mathematics" (PSSM), recognized by mathematics teachers in all countries, it is noteworthy that the standards in the book are similar to the objectives defined in the MoNE and explained above. According to the National Council of Teachers of Mathematics (NCTM), mathematical proficiency consists of process standards encompassing problem-solving, reasoning and proof, communication, connections, and representation (NCTM, 2000). Founded in 1920, NCTM is the largest mathematics education organization. It argues that all students deserve the best mathematics education and can also learn mathematics at an advanced level (NCTM, 2017). In 2000, NCTM published the PSSM, which established and explained the main principles, content, and process standards for mathematics from kindergarten through the end of 12th grade. These standards do not specify a curriculum; they aim to define the concepts that students are expected to understand (content standards) and the skills they are expected to acquire (process standards) (NCTM, 2000). The content standard outlines what should be learned at each level from kindergarten through twelfth grade and is classified into numbers and operations, algebra, geometry, measurement, data analysis, and probability. The standards that emphasize acquiring and utilizing these contents are process standards. Process standards emphasize how students at all levels, from preschool to 12th grade, develop and apply the content. There are five process standards: “problem-solving,” “reasoning and proof,” “communication,” “connections,” and “representation.”

In Türkiye, as in many countries, mathematics teaching aims to develop specific skills in students. Among these skills is the ability for students to develop their strategies for solving various problems, to generalize their solutions and strategies to new problem situations, to create models from difficulties and to associate them with verbal and mathematical expressions, to explain and check their problem-solving process, to formulate problems, to establish relationships between mathematical concepts, to apply problem-solving approaches in understanding mathematical topics, and to use mathematical language appropriately. To achieve all these objectives, students need to learn how to solve problems (Baykul, 2021). In this context, when looking at the mathematics curricula published since 1926, it is observed that the emphasis on the "problem-solving" skill was present in the 1949 curriculum. In other curricula published after 1949, problem-solving skills are also included. However, the curricula from 1949 to 2005 address problem-solving skills in the most detailed manner. In the MDÖP published in 2005, problem-solving skills were given a separate section, and the explanations related to the skill are pretty close to the steps of the problem-solving method (Kömleksiz & Gökmenoğlu, 2020).

Students need to integrate and apply what they have learned throughout the problem-solving process. The focus should not be solely on solving the problem. Accordingly, problem-solving can be defined as a process summarized by Polya (1945) in four stages. These stages are understanding the problem, determining a strategy for the solution, implementing the strategy, and evaluating the solution found. Several fundamental strategies have been identified in the problem-solving process to ensure the correct resolution of problems. These strategies have been identified as "elimination," "guess and check," "drawing diagrams," "using solutions of similar simple problems," "using variables (writing equations or inequalities)," "creating tables," "finding relationships," "working backward," "making systematic lists," "guessing," and "reasoning" (Altun, 2013). Strategies can be shown to students to encourage their application in the problem-solving process. Although it is impossible to solve all problems using a single strategy, some strategies can be utilized more intensively, and different strategies can be employed at various stages of the solution. For students to use strategies effectively, problems should first be presented, and opportunities should be given to identify possible approaches. Since the ability to acquire and apply strategies is related to the student's developmental level, the appropriateness of the teaching level for the strategies should be emphasized (Reys, Suydam, Lindquist, & Smith, 1995). In the study conducted by Kartallıoğlu (2005), students were expected to solve 10 problems assigned to them, and it was observed that they mainly solved the problems involving fractional expressions by drawing diagrams. When students who attempted to solve without drawing a diagram arrived at incorrect answers and were encouraged to create diagrams, it was noted that they recognized their errors and altered their operations when they were redirected to the item.

Arslan (2023) examined the problems in the 6th-grade mathematics textbook and the problem-solving strategies employed to resolve these issues. He noted that the most frequently utilized strategy in numbers and operations is the diagramming strategy, while the table-making strategy is prevalent in algebra. In data processing, logical reasoning strategies are emphasized, and in geometry, there is a significant focus on writing equations or inequalities alongside reasoning. He also remarked that mathematics textbooks have no strategies or instructional content information. In a similar study, Özcan (2024) examined the problem-solving strategies in the solved problems of the middle school math textbooks for grades 6, 7, and 8 published by the Ministry of National Education (MoNE). The study found that the strategy most frequently employed in solving problems was writing equalities or inequalities. However, it was determined that due to the limited number of solved problems in the grade 6 math textbook, strategies were not sufficiently extensive. It was noted that the most issues solved and strategies were found at the 8th-grade level; however, there was no information or instructional content related to any specific strategy in the textbooks. In another study structured around the solved problems found in textbooks, Türkmen (2022) aimed to examine the solved items in the Mathematics Textbooks for grades 5, 6, 7, and 8 within the Learning Area of Numbers and Operations, focusing on problem-solving strategies. One of the research results indicated that in the context of the Learning Area of Numbers and Operations, the problems in the middle school mathematics textbooks for each grade level predominantly incorporated the strategy of drawing diagrams. In contrast, the strategy of working backward was utilized the least.

Studies focused on improving problem-solving skills have found that the intelligence games course positively impacts sixth-grade students' problem-solving strategies and reasoning abilities (Kurbal, 2015). Additionally, the instruction of problem-solving strategies has a beneficial influence on problem-solving (Arslan, 2002; Arsuk & Sezgin Memnun, 2020; Başdamar, 2019), and it is also established that strategies are teachable (Altun & Arslan, 2006; Yazgan & Bintaş, 2005). According to the results of the experimental study conducted by Altun and Arslan (2006) with seventh and eighth-grade students regarding strategy instruction, it was found that seventh-grade students utilized certain strategies to a specific extent before receiving instruction. These strategies included prediction and control (56%), systematic listing (47%), drawing (24%), and simplifying problems (23%). Additionally, they did not employ backward working and relationship-building strategies. In contrast, eighth-grade students were capable of using systematic listing (67%), prediction and control (58%), simplifying problems (35%), and drawing (31%) strategies before receiving instruction; however, they also did not utilize finding relationship and working backward strategy.

Demir (2019) conducted a study with 60 eighth-grade students to determine the strategies students use to solve problems and identify which problem-solving process they make errors. The results reveal that students who solved problems correctly predominantly employed the prediction and control strategy. This strategy was followed, in order, by the drawing representation strategy, the arithmetic strategy, and the making equation formulation strategy. The strategy used least was found to be the table-making strategy. Another recent study aimed to identify teachers' opinions on middle school students' abilities to utilize problem-solving strategies. It concluded that although teachers believe problem-solving strategies provide advantages for students, the students are unaware of these strategies (Cevizci, 2020).

When examining the curricula for middle school mathematics courses, one of the cognitive skills emphasized is reasoning (Doğanay & Uyar, 2020). Similar to the MoNEs, the Common Core State Standards (CCSS, 2010) also emphasizes the necessity of developing higher-order skills such as inference and argumentation (CCSS, 2010; MoNE, 2018). The NCTM (2000) standards address the ability to reason in the standard of "reasoning and proof.", Reasoning and proof should be an ongoing natural part of classroom discussions, regardless of the topic being studied (National Council of Teachers of Mathematics [NCTM], 2000). Proof is the result of logically connecting propositions, and a generalization is considered valid when it can be shown to be a necessary consequence of one or more propositions accepted as accurate (Yıldırım, 2000). Weber (2005) defined proof as a complex mathematical activity with logical, conceptual, social, and problem-solving dimensions. Additionally, he has described proof creation as a mathematical task in which assumptions, actions, and definitions are given to the individual, with the expectation that they will apply inference rules until reaching the desired conclusion. In this study, proof skills were excluded. In this study, only the reasoning processes within the reasoning and proof standard have been examined since the LGS items are in multiple-choice format.

There are various definitions regarding reasoning approaches in the literature. Lithner (2008) developed an analytical framework that considers multiple dimensions of reasoning while classifying mathematical reasoning. In this context, Lithner (2008) focused on two components, "imitative reasoning" and "creative reasoning," in his study conducted within the framework of mathematical reasoning. Imitative reasoning encompasses algorithmic reasoning and "memorized reasoning, where algorithmic mathematical reasoning is further explored in terms of known, constrained, and guided algorithmic mathematical reasoning. In creative mathematical reasoning, a new solution is found; in algorithm-based mathematical reasoning, a learned or demonstrated method is followed; and in rote-based mathematical reasoning, the correct result is instantly reached through recall. The foundation of creative mathematical reasoning lies in plausibility and logical values, but when using "algorithm-based reasoning" and "rote-based reasoning," the imitated knowledge is not questioned. (Lithner, 2008). In the study examining the mathematical reasoning process within the 7th-grade algebra learning area, Öz (2017) based her work on Lithner's (2008) theoretical framework. It has been observed that when students encounter problems, they rely more on algorithm-based mathematical reasoning than on analogy-based reasoning. Additionally, the study noted that teachers provided limited support for mathematical reasoning, and insufficient opportunities in the learning environment hindered the development of students' mathematical reasoning skills.

Doğan (2019) revealed in a study examining mathematical reasoning and proof activities in eighth-grade mathematics textbooks that the content related to proof was 5.3% in algebra, 11.8% in numbers and operations, 7.4% in geometry and measurement, and 7.8% in probability. It has been noted that there is no content related to proof in data processing. The research results indicate that the eighth-grade mathematics textbook is insufficient in reasoning and proof and that students have limited access to activities requiring reasoning and proof. In another study, Şengül and Kıral (2023) evaluated textbook activities regarding reasoning and proof. They found that activities related to reasoning and proof constituted 21% and 13% of all activities in the fifth and sixth-grade mathematics textbooks, respectively. As a result, it was observed that reasoning and proof do not occupy a significant place in the activities of mathematics textbooks. In addition to these studies that revealed the limitations of the content related to reasoning in textbooks, Çakıroğlu, Kohanová, İşler-Baykal, Slavíčková, Di Paola, Michal, and Høynes (2023) conducted a study to reveal the resources teachers in five countries used to teach reasoning and proving and the limitations of these resources. According to the research results, although there were similarities and differences between countries, they determined that textbooks, other books, and teachers' materials were almost universally the most used resources to teach reasoning and proving.

Communication is another crucial process standard. Since 1926, all middle school mathematics curricula have emphasized mathematical communication and aimed to enhance this communication alongside developing various skills. In this process, it has been observed that the 1977 curriculum adopted a teacher-centered approach, with teachers being more active than students. However, beginning with the programs implemented in 2005, students became more active participants (Erdoğan & Yazlık, 2020). The importance of using mathematical language and facilitating communication in the classroom has also been highlighted by NCTM (2020). In the study on the use of mathematical language, Yalvaç (2019) stated that students can convert verbally described events into formal language. However, they encounter difficulties with problems that require using tables and graphs. To enable students to analyze and evaluate mathematical thinking, it is essential to develop mathematical communication skills. Various studies have been conducted within the framework of mathematical language and teaching (Brenner, 1994; Goslin, 2016; Herbel-Eisenmann, Choppin, Wagner, & Pimm, 2011; Lesh, 1981; Marzano, 2004; Pimm, 2019; Purpura & Reid, 2016; Riccomini, Smith, Hughes, & Fries, 2015).

One of the necessary skills for learning mathematics and performing mathematical tasks is the skill of association (Chapman, 2012; MoNE, 2018). When looking at the mathematics curricula during the Republic period, it has been observed that the importance of association is emphasized in every program. The first program to consider association as a skill is the 2005 MoNE (Gürbüz & Şahin, 2020). One of the classifications on mathematical association belongs to the study by Bingölbali and Coşkun (2016) and is discussed with examples in Table 1.

Table 1. Making Connections, Indicators, and Examples (Bingölbali & Coşkun, 2016)

Main Component	Sub-component	Indicators	Example
Making connections between concepts	Making connections between concepts and other concepts	The use of other concepts in the teaching of the concept/mathematical expression	"When calculating the length of the arc segment corresponding to a certain central angle of a circle, proportion is used. More specifically, if the circumference length for 360° is $2\pi r$, then the length of the arc segment for an angle α is $2\pi r\alpha/360$."
	Making connections between a concept and its sub-concepts and among sub-concepts themselves.	The use of hierarchy or relationships between the central concept and its sub-concepts in teaching. Making connections among the sub-concepts of the central concept.	"An equilateral triangle is a triangle in which all angles are 60 degrees, and all sides are equal." "An equilateral triangle is also classified as an acute triangle."
Making connections between different representations of the concept.		Connect between at least two different representations (such as table-graphic, equation-graphic, verbal expression-equation, symbolic representation-image-model, concrete object-verbal expression, etc).	"The algebraic representation of the expression 'three times a number plus seven equals forty-five' is $3x + 7 = 45$." "1/5 represents a unit fraction, which can be concretely demonstrated through the cake brought to class, modeled using a circular shape, and read as 'one-fifth.'"
Making connections with real life	Addressing the concept within a specific context	The use of problems or examples that incorporate real-life contexts. Teaching through concrete models or simulations.	"What is the difference between the arithmetic averages of the ages of the girls and boys in our class?" "The number -10 is equivalent to being in debt to someone by 10 Lira." The number +10 is like having 10 in our pocket. "The concept of equality is explained through the idea of a balance (either concrete or simulated)."
	Providing verbal examples from real life.	The relationship between a concept/expression and real life is verbally articulated.	"We can observe the embellishments created through the movements of reflection, rotation, and translation in the patterns of our home carpets and Ottoman architectural works."
Making connections with different disciplines	Making connections with different disciplines.	Teaching mathematical concepts and expressions through the context of a different discipline.	"Introducing the concept of derivatives based on determining the instantaneous speed of a moving object."
	Expression of connections with different disciplines through verbal examples	The verbal articulation of the relationship of the concept with various disciplines. The application of mathematics across various disciplines is articulated solely in verbal terms.	"The concept of 'rate' is used in the natural sciences to explain the concepts of speed and density."

Mumcu (2018) addressed mathematical relational skills within the framework of derivatives, noting that the participants' knowledge was largely rote and that they struggled to relate and contextualize this knowledge effectively. In another study, Dilegen (2018) examined two 5th-grade mathematics textbooks, one published by the Ministry of Education (MoNE) and one by a private publisher, focusing on the categories of real-life connections, correlations between different representations of concepts, correlations between concepts, and connections with other disciplines. The results noted that the most significant emphasis was on real-life connections and inter-conceptual correlations, while less attention was given to the correlation between different representations of concepts. Furthermore, it was stated that no attention was paid to the correlation with other disciplines in either of the textbooks. The study revealed a lack of comprehensive focus on the skill of relationship-making.

According to NCTM (2000), mathematical expression is related to the student's ability to interpret the problem. To succeed in problem-solving, it is necessary to create appropriate problem representations and use them to help understand the situation and its relationships (Cifarelli, 1998). In the 2005 MDÖP, problem-solving skills were addressed as a separate section. Students have examined the information they use when solving problems, how they represent them (such as with concrete objects, shapes, and tables), and how this representation facilitates problem-solving (Şeker, 2019). Students may prefer representations for various reasons. These reasons depend on the student and the subject. Each student may use a different representation for the same or similar item. For example, while some students prefer verbal representations, others may use concrete objects (Fennell & Rowan, 2001). Gürbüz and Şahin (2015) investigated the transition between representations in algebra learning. They discovered that students had the most difficulty transitioning from other representations to graphs. According to the research results, the easiest type of transition is the transition to a table. İpek and Okumuş (2012) observed a similar result in their research. They discovered that the spoken language representation was utilized more than all other representations. However, they observed deficiencies in creating representations related to the problem and transitioning between different representations. A similar result is found in Tanju's (2020) research, where it was observed that all the mathematics teacher candidates participating in the study predominantly used verbal explanations in their proposed solutions for problem-solving. In this study, Tanju (2020) highlighted the significance of associative and representational skills in the problem-solving phase by examining the types of mathematical associations and representations utilized by prospective mathematics teachers during the mathematical modeling process. The research results emphasized the importance of establishing connections between mathematical concepts and the representations of real situations. Özaltun, Hıdıroğlu, Kula, and Bukova Güzel (2013) also indicated in their research that students predominantly utilized verbal representations. Furthermore, they stated that using visual (graphical) representations during the problem initiation phase aided students in understanding and interpreting the problem.

Umay, Akkuş, and Duatepe (2006) conducted a study on the standards published by NCTM. They examined the mathematics curriculum from 1st grade to 5th grade. The study concluded that the curriculum is designed for understanding-based learning and aims to enhance learning through critical thinking. However, they have noted that, in addition to the similarities, some principles and criteria in the curriculum do not meet the principles and standards developed by the NCTM. Assessment is used to determine educational programs' accuracy, adequacy, competency, effectiveness, efficiency, and success (Uşun, 2016). In our country, centralized exams are conducted to measure students' levels of attainment and success in the outcomes specified in educational programs. These exams have varied throughout our educational history. Until 1997, centralized exams were administered to students after the 5th grade. However, starting from 1997, these exams began to be administered after the 8th grade along with the eight-year compulsory primary education system (Aslan, 2017). These examinations have been named as follows: in 1997, the Transition to High Schools Examination; in 2005, the Examination for Secondary Education Institutions (OKS); in 2008, the Level Determination Examination (SBS); in 2014, the Transition from Primary to Secondary Education (TEOG); and in 2018, the ongoing Central Examination for Secondary Education Institutions that admit students through examination (LGS) (Çelik, 2023).

One of the studies examining the central exams conducted for the transition to secondary education is by Köğce and Baki (2009). They compared a total of 290 mathematics items from the quantitative section of the ÖSS, administered between 1995 and 2004, with 959 mathematics items developed by participants who were teachers at a general high school, two Anatolian high schools, a science high school, a vocational and technical high school, and a commerce vocational high school during the 2003-2004 and 2004-2005 academic years, using Bloom's Taxonomy as a framework. It was found that the mathematics items in the ÖSS did not align cognitively with the items posed in the commerce vocational, technical, and multi-program high schools. In contrast, there was cognitive alignment with the items posed in the Anatolian and science high schools. Uğurel, Moralı, and Kesgin (2012), examining the mathematics items in the OKS and SBS exams, which are part of the transition to secondary education after ÖSS, investigated the items within the framework of the MATH Taxonomy, as well as the TIMSS (Trends in Mathematics and Science Study). The data for the research comprised the mathematics items from the OKS, administered to 8th graders in 2008; from the SBS, administered to 6th, 7th, and 8th graders in 2010; and from the TIMSS, which took place in 2007. It was found that the items predominantly featured information transfer in SBS-6, routine processes in SBS-7, a combination of routine processes and information transfer in SBS-8, adaptation to new situations in OKS, and items containing information at the level of routine processes in TIMSS. Another study was conducted by Güler, Özdemir, and Dikici (2012).. Güler et al. (2012) compared the exam items prepared by primary school mathematics teachers during the 2009-2010 academic year with the SBS mathematics items administered to 6th, 7th, and 8th graders in 2010. Examining teacher-created exams alongside the SBS exam items aimed to gather information on how these assessments comply with the regulations governing primary education institutions. The results indicated that in the exams prepared by teachers, items at the knowledge level for 6th grade, the application level for 7th grade, and the comprehension level for 8th grade were prevalent. It has been determined that there are more application-level items for 6th, 7th, and 8th grades in the SBS mathematics items.

Dalak (2015) researched the secondary education transition exam known as TEOG following SBS and examined all the items in the two TEOG exams administered in the 2013-2014 academic year. He examined the extent to which the items asked in the exam aligned with the 8th-grade achievements in the Middle School Curriculum Framework according to the Revised Bloom's Taxonomy. It was found that 55% of the items were at the same cognitive level and knowledge dimension as the relevant achievements. However, it has been observed that the items and related achievements are in procedural and conceptual knowledge dimensions. At the same time, there are no items about the achievements related to metacognitive and factual knowledge. Mutlu and Akgün (2016) examined all the OKS and SBS exams conducted between 1998 and 2013, analyzing a total of 375 mathematics items from both assessments within the framework of categories characterized by PISA related to real-life situations and the learning areas included in the middle school mathematics curriculum. The number of real-life-related items between 1998 and 2008 is almost half of the number of real-life-related items between 2009 and 2013. Additionally, when examining the distribution of items by learning areas, it has been observed that there has been at least an item related to each learning area in recent years' assessments.

Research has been conducted on various aspects of the mathematics subject included in the LGS central exam. When examining the literature related to the analysis of mathematics items in the transition exams to secondary education (LGS), it has been observed that the research has been conducted within the framework of Bloom's Taxonomy (Köğce & Baki, 2009), Revised Bloom's Taxonomy (Dalak, 2015; Ekinci & Bal, 2019; Yılmaz & Doğan, 2022; Demir 2023), MATH Taxonomy (Baydar, 2019; Uğurel et al., 2012), the compatibility with the achievements, learning areas, and specific objectives aimed to be attained by students in the MDÖP (Bağcı, 2016; Baydar, 2019; Dalak, 2015; Ekinci & Bal, 2019; Mutlu & Akgün, 2016; Ünal & Eroğlu, 2021; Yılmaz & Doğan, 2022), PISA mathematics literacy levels (Öztürk, 2020), cognitive domains of TIMSS (Baydar, 2019), comparisons with other exams (Baydar, 2019; Dönmez & Dede, 2020; Güler et al., 2012; Köğce & Baki, 2009) and mathematical proficiency and cognitive demand (Aydın, 2024).

In these studies, Demir (2023) examined the cognitive processes and knowledge domains of the LGS mathematics exam items administered between 2018 and 2022, as well as the assessment items included in the 8th-grade mathematics textbook, within the framework of the Revised Bloom's Taxonomy. It was found that the LGS items were positioned at higher-order cognitive and procedural levels. In contrast, the findings indicated that the majority of the assessment items in the textbooks were situated at lower-order cognitive and procedural levels. Aydın (2024) seeks to examine the mathematics test items included in LGS examinations held from 2018 to 2023, focusing on assessing mathematical proficiency components, cognitive demand levels, and various representations' utilization. Consequently, an analysis of the mathematics items in the LGS examinations from 2018 to 2023 reveals a strong emphasis on mathematical proficiency components, mainly showcasing a notable focus on adaptable reasoning. Additionally, research indicated that items focusing on procedural fluency often require a deep understanding of concepts, while items requiring strategic competence typically call for proficiency in concepts and procedures. Moreover, research has shown that the majority of mathematical items in the LGS exams held from 2018 to 2023 require substantial effort in terms of interconnected processes. Öztürk (2020) is among the researchers who analyze the mathematics items in the central exam alongside the items in the internationally conducted exam. The study's data consists of mathematics items from the central exams undertaken in the scope of LGS during the 2018-2019 period. He classified these items primarily using the PISA mathematics literacy proficiency scale. In her qualitative research, she used the document analysis method. The analysis of 40 mathematics items found that not all PISA mathematics literacy proficiency scale levels were represented and that the exams predominantly focused on level 2 items. When the program is examined, it is clear that the importance of students learning to learn and developing problem-solving, communication, and association skills is emphasized.

In their study examining the 2018 curriculum according to process standards, Zeybek Şimşek and Kılıçoğlu (2022) found that the process standards varied by grade level and that different process skills were prioritized across various grade levels, with problem-solving being most closely related to outcomes, while reasoning and proof were associated with the least. Another study was conducted by Büyükalan Filiz and Ergan (2020). The researchers analyzed the learning outcomes of the elementary school mathematics curriculum according to process standards. They determined that the outcomes most corresponded to the standards of association and representation. Similarly, it was found that reasoning and proof were the least associated standards.

The literature shows that studies examining process standards are organized by addressing specific topics or standards. No study examines how the five standards—representation standard, reasoning and proof standard, connection standard, problem-solving standard, and communication standard—are used in exam items. It has been observed that studies investigating the entire process standard are limited to learning outcomes and specific topics included in textbooks and curricula. The central exams of the LGS have started to include skill-based items, which are also defined as new-generation items encompassing higher-order thinking skills. This research aims to determine the process standards that can be applied in solving mathematics items for the Central Exam related to Secondary Education Institutions that admit students through the LGS. Additionally, it aims to examine how these standards are addressed and analyze the items distribution according to the fundamental learning areas. In this context, it is believed that the distribution of mathematics items asked in the LGS according to NCTM process standards, the implementation of these standards, and the examination of sub-learning areas specified in the curriculum for the eighth grade will contribute to the perspectives of field researchers, item writers, teachers, and textbook authors. Additionally, determining the relationship between the process standards of NCTM (McKinney & Frazier, 2008), which has historical roots in developing and expressing professional goals and standards to improve mathematics education from pre-kindergarten to twelfth grade in internationally recognized centrally administered exams, will contribute to data collection for exams conducted in the international arena.

Research Problem

- What are the process standards (problem-solving, reasoning, communication, connection, representation) that can be used in the possible solutions of the Central Exam for Secondary Education Institutions (LGS) to be Admitted by Examination in 2020 and 2021, and how are these standards addressed?

Method

In this study, the mathematics items asked in the Central Exam in Secondary Education were examined through document analysis in the context of the process standards published by NCTM. In document analysis, information and documents related to the subject of investigation are obtained, and these sources are subjected to analysis (Yıldırım & Şimşek, 2005). Studies employing the document analysis method in educational sciences typically contain extensive data and require data collection from multiple sources (Özkan, 2019). Document analysis can also describe and compare observed events where direct access to the relevant individuals is impossible (Aktaş, 2019; Frechtling, 2002).

The first stage of document review is to determine the purpose of content analysis. Then, ideas are identified. Subsequently, a decision is made on what will be analyzed, and the data is selected appropriately for the purpose (Fraenkel, Wallen, and Hyun, 2012). Following these procedures, coding categories are created. In this study, a comprehensive literature review related to all subtopics was conducted to facilitate the analysis of the items, and the coding was done based on the obtained sources. The research data consists of mathematics ques items tions from the LGS exams in 2020 and 2021. The items were downloaded from the publicly accessible website of the Ministry of National Education (MoNE). The literature related to all relevant subheadings was scanned to analyze the items. Based on the obtained sources, a descriptive identification of which process standards are compatible with the items and possible solutions has been made, and a table containing this data has been created.

After the first COVID-19 case emerged on March 11, 2020, the Ministry of National Education (MoNE) announced on March 26, 2020, via the website www.meb.gov.tr, that face-to-face education was suspended in all schools affiliated with MoNE starting from March 14. Students were informed that they would only be responsible for the first semester topics in the exams held in 2020, and it was announced that the exam topics would include factors and multiples, exponential expressions, radical expressions, data analysis, probability of simple events, and algebraic expressions and identities. When examining the scope of the 2021 mathematics items, in addition to the previous topics, algebraic expressions and identities, inequalities, linear equations, triangles, congruence, and similarity topics have been added. This year, items about geometric bodies and transformation geometry have not been included. The topic distributions for both years are presented in Figure 1.

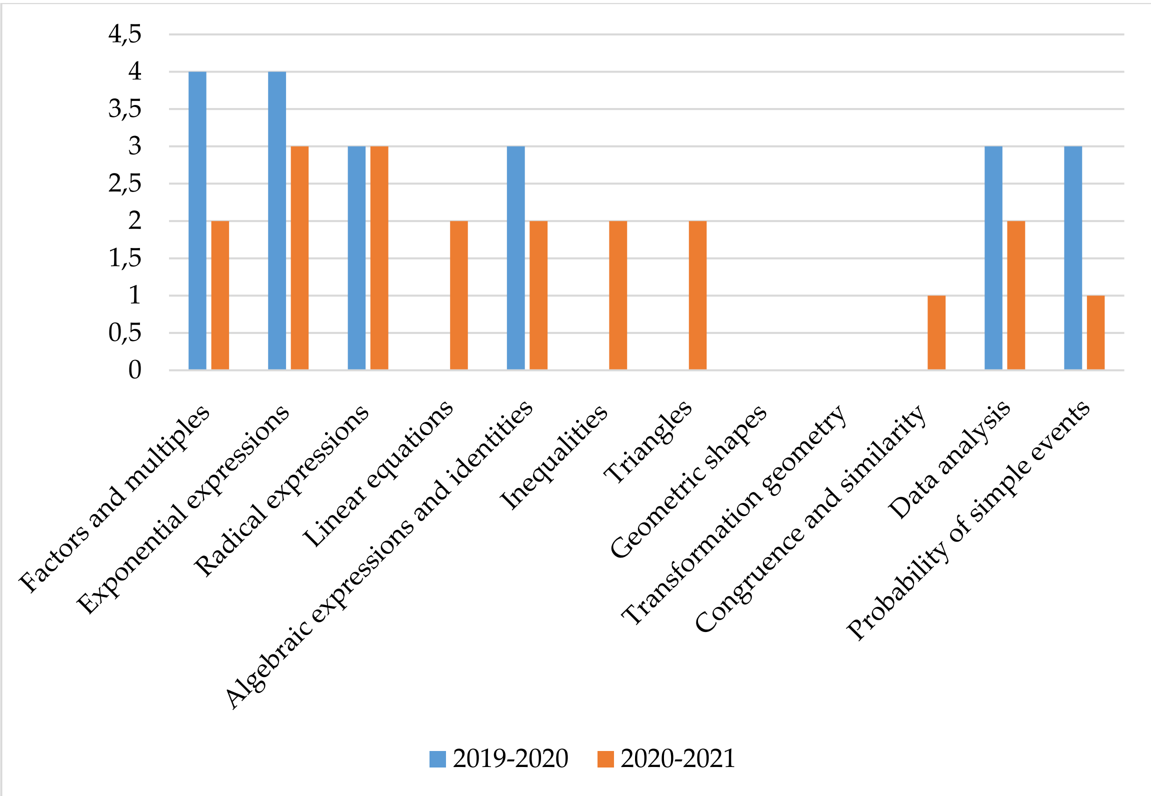

Figure 1. Distribution of 2020-2021 LGS Mathematics Items by Topics.

When examining the graph provided in Figure 1, it is observed that in 2020, there were four items on factors and multiples, four on exponential expressions, three on radical expressions, and three each on data analysis, simple event probabilities, and algebraic expressions and identities. With the public announcement, items have been prepared on all the topics for which students are responsible.

While reviewing the exam items from 2021, the following topic distributions were found: Three items each on exponential and radical expressions and two each on factors and multiples, algebraic expressions and identities, linear equations, data analysis, inequalities, and triangles. An item was about congruence, similarity, and the probability of simple events.

There were no items related to geometric solids and transformation geometry. When a comparison is made for both years, it is observed that in the 2020 exam, among the standard topics, there was a decrease in the number of items in other issues except for data analysis in the 2021 exam. Considering the COVID-19 pandemic, the 2020 exam items, which were structured accordingly, included all the topics announced before the exam. Since the distribution of topics is almost homogeneous, the distribution of topics in this year's exam is appropriate. In 2021, although students were responsible for all the topics included in the curriculum, it can be said that the distribution did not show a homogeneous spread according to the sub-learning areas in the curriculum because there were no items related to geometric solids and transformation geometry.

The study's research item process standards have been examined according to specific theoretical frameworks. The problem-solving standard has identified the following strategies for solutions. These are: "conscious prediction and control, drawing shapes or diagrams, benefiting from the solutions of similar simple problems, using variables (formulating equations or inequalities), creating tables, finding patterns, working backward, making systematic lists, using logical reasoning, and developing different perspectives." To classify, all possible solution paths for the problem were evaluated, and the strategies used for each solution path were coded. Strategies were examined only for potential solutions.

In examining the reasoning and proof standards, it was deemed appropriate to use the components of imitative and creative reasoning proposed by Lithner (2008) in the studies conducted. Analyses were performed using formal mathematical language through the dimensions of expression via graphs, shapes, and tables, as well as non-formal language. The classification developed by Bingölbali and Coşkun (2016) pertains to the skill of association and serves as a classification for the making connection standard. The identification of the use of the representation standard has been accomplished through various means such as table representation, image representation, numerical representation, algebraic representation, diagrams, and graph drawing. The representation standard has also been examined within the framework of items and their potential solutions. Like problem-solving strategies, multiple codings can be included for a single item regarding reasoning types, representation types, and types of association and communication.

This study was conducted based on the literature review obtained by the research problems and sub-problems. The exam items were distributed as ten items each to four elementary mathematics teachers who teach eighth-grade mathematics, aiming to consider different strategies. They were subsequently compared with the solutions provided by the researcher. Finally, all items were resolved with a consulting teacher, an expert in mathematics education, and coded according to the identified sub-learning areas and process standards. The items were coded to indicate the year they were administered and their item number. The items have been coded to describe the year they were administered and their item numbers. For example, the fifth math item in the central exam conducted in 2020 is coded as 1.S5, and the fifth item in the exam for 2021 is coded as 2.S5.

The exam items were reviewed three times by two eighth-grade subject teachers and a mathematics education expert to enhance the reliability of the research. The reliability of qualitative research is typically determined by the level of similarity in datasets coded by different coders. According to a coding audit that checks for internal consistency, the inter-coder agreement is anticipated to be at least 80% (Patton, 2002). When examining the percentage of coding agreement among researchers, it has been found that 85% of the same codes and themes were identified. Differences arising in the coding of process skills were discussed between the researchers until a consensus was reached. Figure 1 below shows an item from the problem-solving standard. The solutions to these items by two teachers and the appropriate problem-solving strategy are explained.

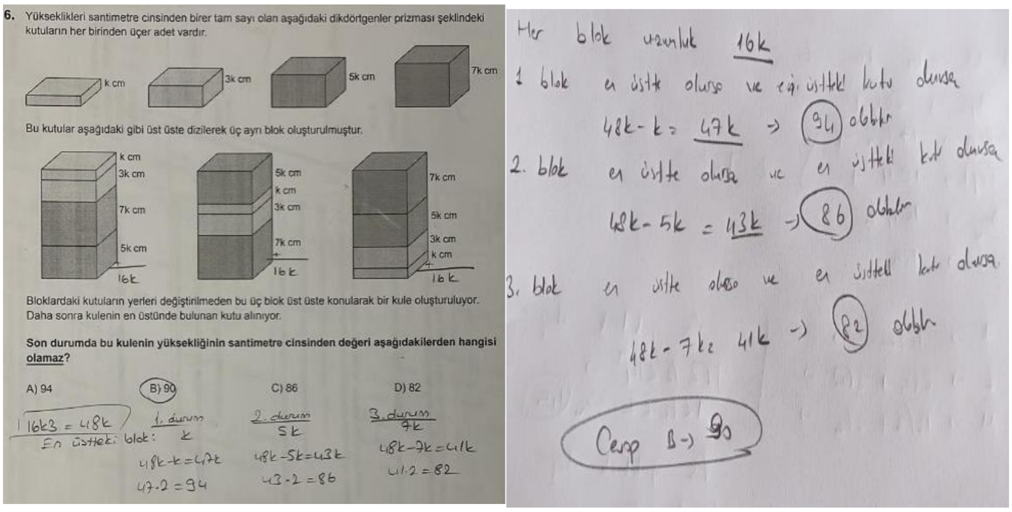

Figure 2. An Item Solvable with Different Strategies for the Year 2020

As seen in Figure 2, it is observed that the teachers reached the solution using the same strategy. Possible solution strategies for the item are conscious prediction and, checking and systematic listing. Each tower will have a height of 16k, and when these towers are stacked on top of each other, they will reach a height of 3x16k=48k. Subsequently, three scenarios will be listed, and it can be hypothesized that the obtained values of 47k, 43k, and 41k will allow the variable "k" to be substituted with 2, leading to the realization that it will not be possible to obtain the number 90. This problem employs multiple strategies within a single solution.

To ensure the study's validity, a detailed analysis framework suitable for the research objective, including appropriateness, significance, and utility, was provided under the data analysis for each process skill (Fraenkel et al., 2012). In light of the aforementioned, it can be concluded that the study meets the criteria for both validity and reliability (Yıldırım & Şimşek, 2005).

In the analysis of the 40 mathematics items covered in the research, based on process skills, the strategies for problem-solving identified in the literature include conscious prediction and control, drawing diagrams or figures, utilizing solutions to similar simple problems, using variables to establish, making table, identifying patterns, working backward creating systematic lists, engaging in logical reasoning, and developing different perspectives. For reasoning, Lithner (2008) employs a framework of mathematical reasoning, while Bingölbali and Coşkun (2016) utilize mathematical association indicators developed based on research in the field according to the literature for types of communication used formal language was used to express through graphics, tables, and figures, and informal language terminology was used. Based on this, the types of representations are also addressed as follows: Table, image, and diagram, numerical, algebraic, and graphical. A portion of the table used for the analysis of the items is presented in Table 2 as an example of how the analysis was conducted. It includes five randomly selected sub-dimensions of the process standards and the cognitive behaviors that rationalize the items for these sub-dimensions.

Table 2. Cognitive Behaviors Used for the Analysis and Coding of Items

Subdimensions of Process Standards	Cognitive Behaviors
Finding Pattern (Problem Solving)	Use of the information that rectangles are drawn in a specific order (1.S15) seeing that after finding the common multiples of 3 and 5, they will increase by 15 each time (1.S8) The white balls increase by four in the sequence 80, 84, 88(1.S16) Noticing that the colors repeat in 5 colors (2.S14)
Making connections between a concept and its sub-concepts and among sub-concepts themselves.	The relationship between showing in a pie chart and a bar chart (1.S2) The relationship between ordering and place values in decimal representation (1.S3) Addition of square root expressions and moving the number outside the root into the root (1.S4) The probability of an event occurring in a possible situation; the relationship of operations with exponential expressions in terms of exponential expressions (2.S14) The ratio of similarity has been associated with Pythagoras; the relationship between triangle and rectangle (2.S15) The slope and Pythagorean theorem have been associated with the triangle; in the solution, percentage can be related to rational numbers (2.S19)
Expressing with graphs, tables, and figures (communication)	Expressing data in a table and reading the graphs provided in the item (1.S13) Interpretation of the given shape (1.S14) Reading the given table (1.S18) Showing the side lengths and areas on the given shape (1.S19) The interpretation of the given graphs can be facilitated by using a table in the solution process(1.S20) The provided information is shown in the table. Visual communication must be established to read the table (2.S4) Understanding the given shape to draw the subsequent stages (2.S5)
Image and Diagram (Representation)	Expressing the length represented by the long side and the short side on the figure (1.S5) Expression of the problem situation in the given form (1.S15) Problem: The mathematical situation described in the problem is presented as a diagram (1.S19) Interpretation of the given shapes (2.S2) Interpretation of the given shape and depiction of the final state (2.S5)
Mathematical Reasoning (Familiar Algorithmic Reasoning)	Reached the correct answer by commenting, "The slice with the highest degree in the pie chart should have the highest column in the bar chart (1.S2) Knowledge of the formula to be used for the solution (2.S2)

Results

According to the sub-research item, the potential solutions to the mathematics items in the LGS implemented in 2020 and 2021 have been examined, distinguishing between items that are considered problems and those that are not deemed as such. Accordingly, it was found that 18 items from 2020 and 19 items from 2021 were in accordance with the problem-solving standards. Figure 3 presents the distributions of the potential solutions to the LGS mathematics items administered during the examined years, classified according to problem-solving strategies.

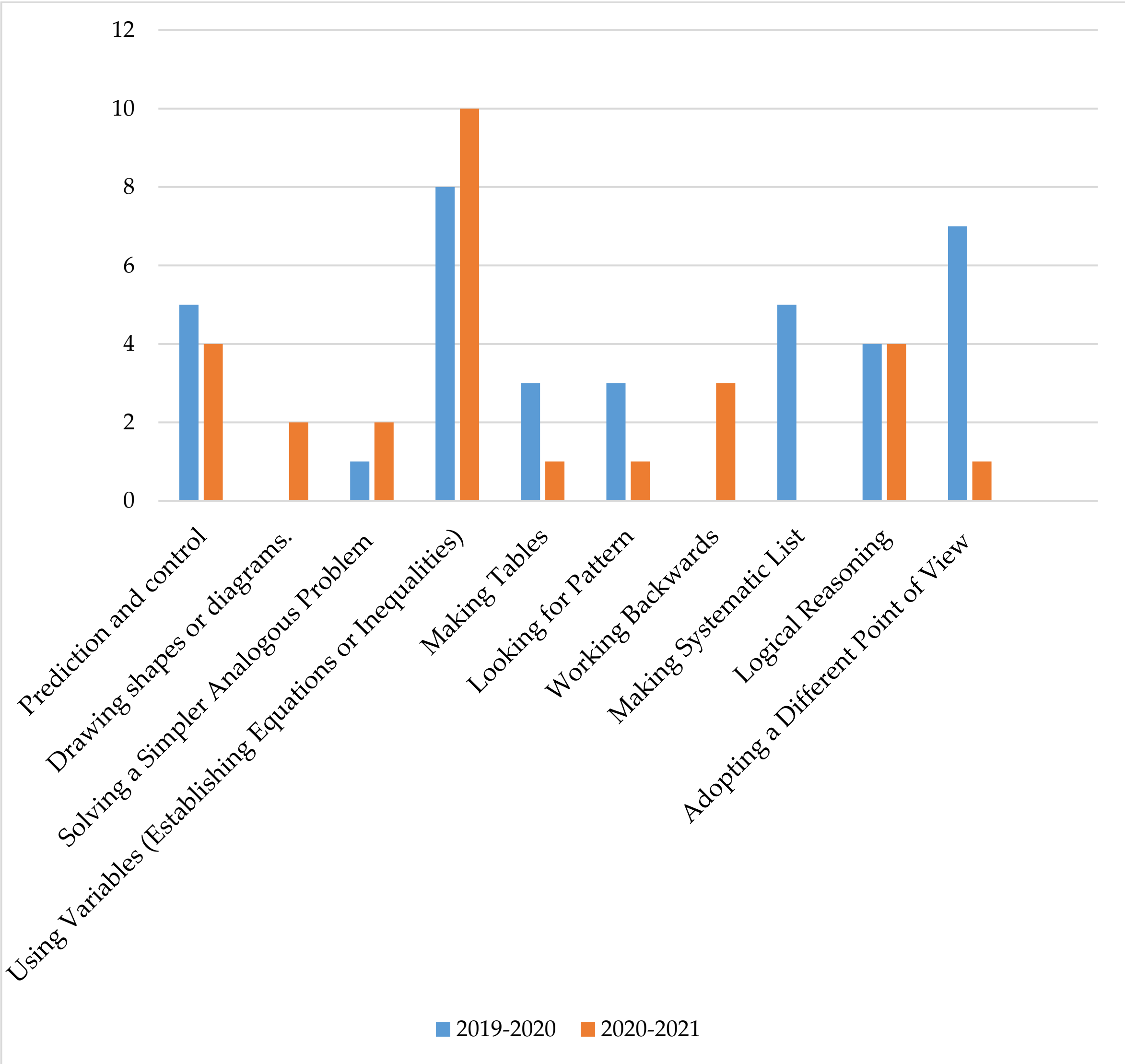

Figure 3. Distribution of Possible Solutions to LGS Mathematics Items According to Problem-Solving Strategies

When examining the graph, it is observed that the use of variables in the solutions is more prominent in both years. In addition, the diversity of strategies is greater for both years. It is observed that items serving the use of drawing shapes and diagrams, as well as the backward working strategy, were not included in the exam for the year 2020. In the other year, no item was asked about using the systematic listing strategy for its solution. In 2020, the number of items aimed at developing different perspectives is higher. This situation can be interpreted as an increase in the number of items requiring different perspectives on the same topics due to the narrowing of the scope.

In some items, multiple strategies were used within the same solution, while in others, different strategies were used in different solutions. In the 2020 and 2021 exam items, a comparison was made between the number of items that used multiple strategies by examining the possible solutions of the items from those years. Accordingly, the number of items that could be solved using various strategies in the 2020 exam is greater than in the 2021 exam. The ability to solve a problem using multiple problem-solving strategy has also led to including that item in different categories of reasoning, representation, association, and communication. This situation has also been considered when creating the graphs for the other standards. The results obtained for the reasoning standard are presented in Figure 4.

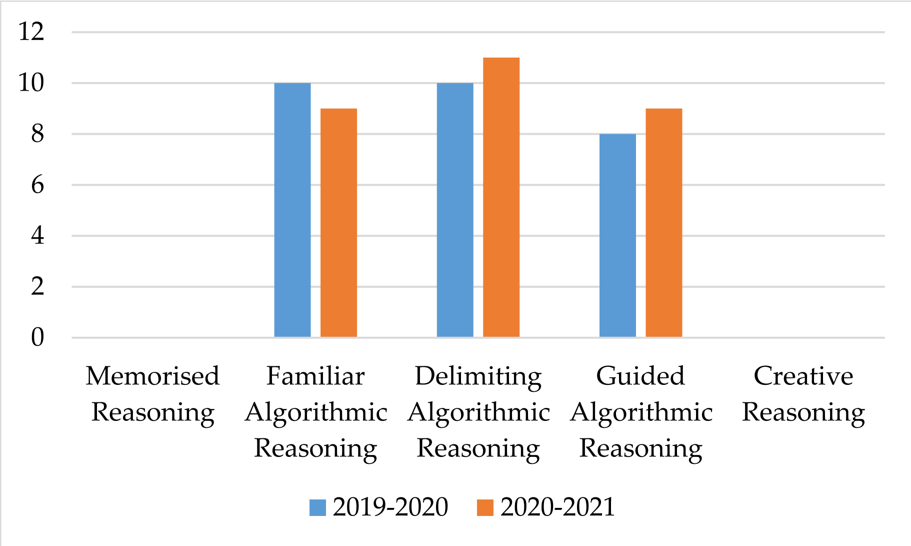

Figure 4. Distribution of Possible Solutions to LGS Mathematics Items by Types of Reasoning

The graph shows that there are no items based on memorized mathematical reasoning and creative mathematical reasoning in either year. Based on this finding, it is stated that the exam cannot be solved solely by memorization. In addition, the items do not require the student to develop a new strategy/formula during that process. The multiple-choice structure of the items aligns with this finding. The distribution of items by type of reasoning in different years shows similarity. The frequency value here indicates all possible solution paths evaluated regarding reasoning. Items requiring known, guided, restricted algorithm-based reasoning were asked for both years.

Figure 5 shows the distributions of the possible solutions to the LGS mathematics items in 2020 and 2021, categorized by types of connections.

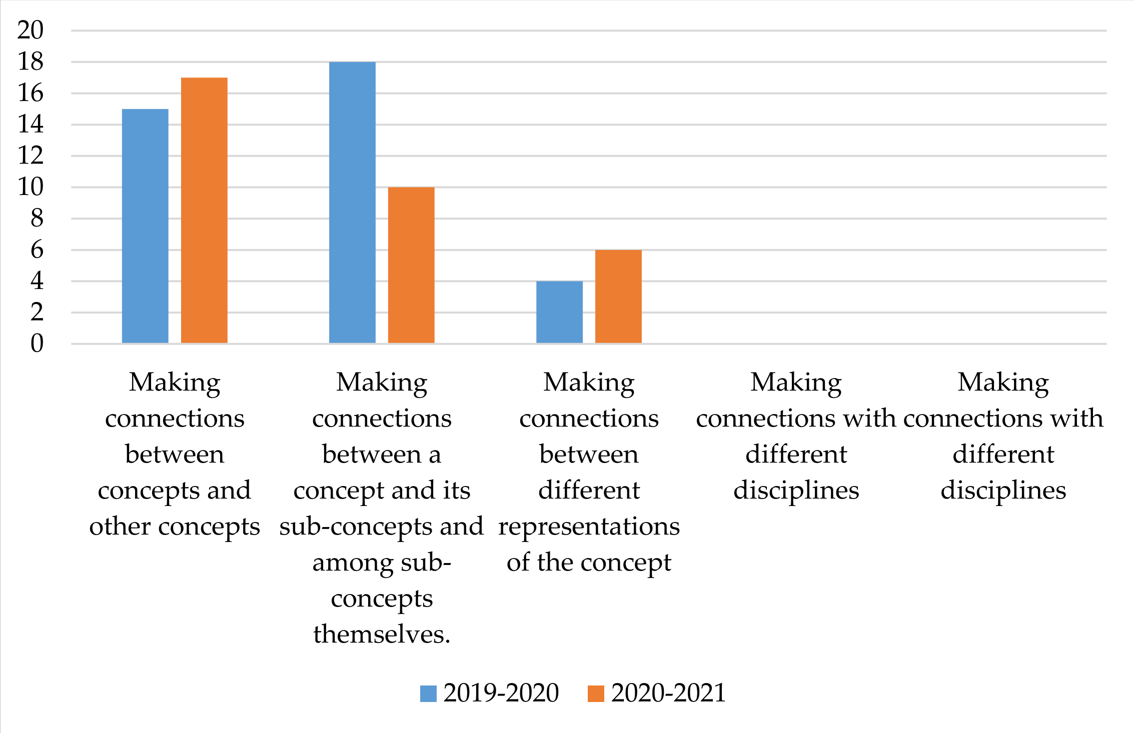

Figure 5. Distribution of Possible Solutions to LGS Mathematics Items by Type of Connection

When examining the graph, it is observed that the relationship between concepts increased from 15 items in 2020 to 17 items in 2021, and the relationship between different representations of the concept rose from 4 items in 2020 to 6 items in 2021. In contrast, the relationship between the concept and its sub-concepts, as well as among the sub-concepts themselves, decreased from 18 items in 2020 to 10 items in 2021. While the most common type of relationship in potential solutions in 2020 was between the concept and its sub-concepts, it shifted to the relationship between different concepts in 2021. The "approach of considering the concept within a context" was examined solely in problematic situations.

The distribution of the possible solutions to the items according to the communication standard is presented in Figure 6 below.

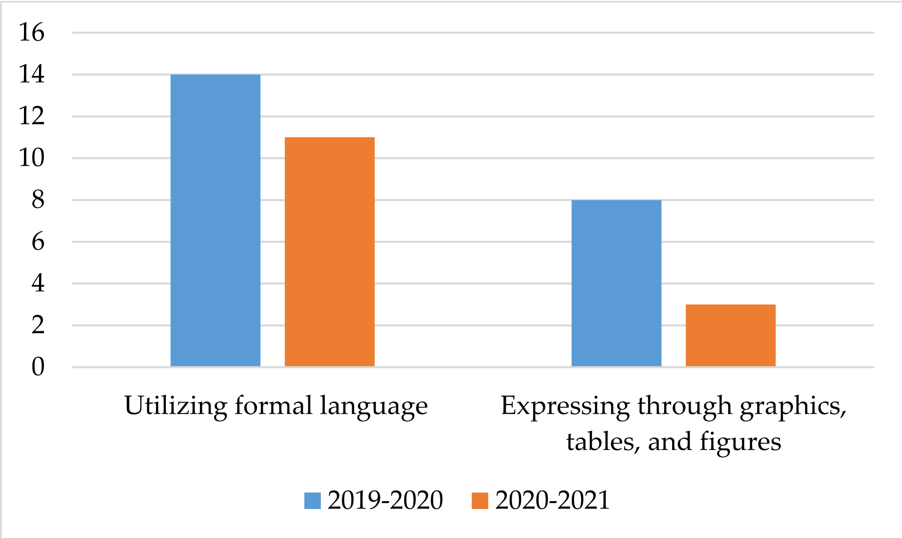

Figure 6. Distribution of Possible Solutions to LGS Mathematics Items by Communication Type

The types of communication used in item solutions can be seen in the graph above. In 2020, 14 situations were identified where formal language would be used , while for the exam conducted in 2021, 11 situations were identified. Expressing with graphs, tables, and figures: In 2020, 8 instances were identified; in 2021, 3 instances were identified. It is observed that the types of communication used in the solutions in 2021 were less prevalent compared to the previous year. It has been determined that formal language was the most used in both years. In both years, it was observed that formal language was the most commonly used communication language in possible solutions. The distribution of potential solutions to the items of another process standard, multiple representations, according to the types of representation, is presented in Figure 7.

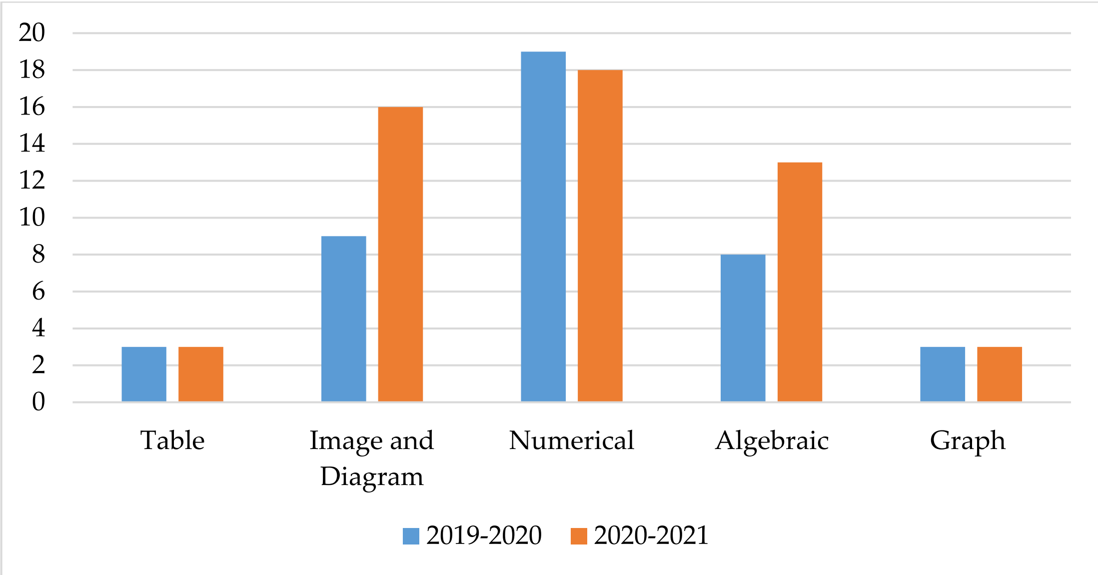

Figure 7. Distribution of Possible Solutions to LGS Mathematics Items by Representation

When the graph is examined, it is observed that numerical representation is present in 37 out of 40 items. The second type of representation that could be used more in the possible solution methods of the items is algebraic. The use of numerical and algebraic representations shows similarities over the years. Table and graph representations are three items for 2020. In 2021, the number of table and graph representations are also equal. In 2020, there were no pictures and diagrams, but the following year, it increased to 2 items.

Discussion and Conclusion

From the research results, it was observed that for a total of 40 items examined, two items in the 2020 exam did not align with the problem-solving standard, while in the 2021 exam, this was the case for 1 item. When examining the possible solutions to the remaining items and analyzing them according to problem-solving strategies, it was determined that the most frequently used strategy in both years was using variables (setting up equations or inequalities). In the possible solutions of the 2020 exam, it was observed that no items served the use of drawing figures and diagrams or working backward strategies. However, in 2021, there were two items where the strategy of drawing figures or diagrams could be used. Regarding the pattern-finding strategy, it was observed that it could be applied to 3 items in 2020 but only to 1 item in 2021.

However, the presence of items that can be solved with multiple strategies in both years and the availability of problems suitable for almost every strategy emphasizes the importance of understanding and using various strategies, considering students' differences (Büyükalan Filiz & Ergan, 2020). This situation supports research showing that different students can benefit from various strategies for a single problem and that multiple strategies can be used simultaneously (Büyükalan Filiz & Ergan, 2020; Yazgan & Arslan, 2020). Additionally, students may fall into the misconception that problems can be solved with a single method depending on their characteristics (Posamentier & Krulik, 2019). The results of the study are consistent with this idea. According to NCTM (2000), educational programs should allow students to apply different and valuable strategies for problem-solving. The application of almost all problem-solving strategies in the items included in the research indicates that the LGS is suitable for this purpose. Yılmaz (2024) has determined that, in addition to different solution strategies in textbooks, most of the tasks in the books are primarily focused on applying definitions or formulas. However, another significant finding is that very little space is given to solution strategies that would help develop problem-solving skills. Similarly, another study has also revealed no information or explanation of any strategy in the textbooks (Özcan, 2024). Zeybek, Üstün, and Birol (2018) stated that the number of problem-solving and problem-posing activities is relatively low compared to activities related to other standards at all grade levels and that in the 7th and 8th-grade levels, problem-solving and problem-posing activities are either not included at all or are included in tiny numbers. While the development of solution-oriented strategies is fundamental in selection exams, certain limitations in the current textbooks are concerning at this point.

According to Cevizci's (2020) research on middle school teachers' views regarding students' problem-solving skills, teachers believe that problem-solving strategies are beneficial for students even if the students themselves are not aware of these strategies. Problem-solving strategies can be taught using appropriate methods. (Altun & Arslan, 2006; Yazgan & Bintaş, 2005). The study aims to evaluate LGS mathematics items based on problem-solving strategies. In light of the results, it has been concluded that the solutions to the items addressed over the two years examined required multiple problem-solving strategies. The importance of learning strategies, the limited content in current textbooks, and the attitudes and beliefs of teachers make this research's conclusion noteworthy.

From the results related to reasoning, it has been observed that there is no problem where creative mathematical reasoning and rote-based mathematical reasoning are employed. Lithner (2004) stated that 70% of textbook exercises focused on algorithm-based mathematical reasoning, while only 10% emphasized creativity-based mathematical reasoning. The result of the research parallels this finding.

In the study conducted by Ergan and Filiz (2020), it was stated that there is no achievement related to explaining mathematical claims in the primary school mathematics curriculum and only a single achievement associated with the use of proof. In another study conducted by Zeybek, Üstün, and Birol (2018), it was noted that among the 2831 mathematical activities found in textbooks used at all middle school grade levels, only about 6% included the reasoning and proof process. These results parallel the results for creativity-based mathematical reasoning and proof obtained from this study. It can be said that there are limitations regarding this process standard in both curricula and textbooks. In addition, the fact that the LGS exam items are in multiple-choice format, considering the limited time and the purpose of the exam, makes it expected that there are no items requiring creative mathematical reasoning in centralized exams. The absence of memorized reasoning indicates that the items not only measure conceptual knowledge but also emphasize the importance of having the ability to apply what has been learned.

However, when looking at the distribution of exam items by types of associations, it is observed that 17 items were presented with real-life situations in both years. This, in turn, can help in concretizing and making sense of the abstract discipline of mathematics; it facilitates students' understanding of how various topics are applied in daily life, enabling them to grasp problems better. When looking at the daily life contexts addressed in the items, it is seen that contexts from daily life are used, such as the length of railway lines as square roots; the area of playgrounds as algebraic expressions, the height of boxes; types of food and portions as graph types; and the amount of food portions. The following year, contexts based on relating daily life situations, such as the square root of a ruler's length, the length of a side as an algebraic expression, and the number of tourists in exponential notation, were used.

Studies conducted with process standards focus on enabling students to reason during the problem-solving process and developing this skill, aiming for students to use these skills in real life (Verschaffel, De Corte, & Vierstraete, 1999). Altun (2006) emphasizes that learning should occur within a context and be connected to real-life examples. These research results also show that the items have the potential to enable students to relate to real life and use their reasoning skills to reach conclusions.

When looking at the results related to the association standard, it is noteworthy that there is no item associated with different disciplines in either year. The exam contains items in six different areas. A mathematics item related to the Science field can create confusion in the definition of the field. This situation and the aim of facilitating students' focus on the solution are considered reasons for not including interdisciplinary items. In both years, it has been observed that the situations where concepts and sub-concepts are related to each other in the items are less than the situations where the idea is related to other mathematical concepts. The relationship between measuring length and numbers is a frequently used example of establishing a connection between a concept and different concepts. Tartan and Erşen (2024) similarly stated in their study that the activities found in textbooks are most often related to daily life and that there is a limited number of instances where they are associated with different disciplines at the 7th and 8th-grade levels.

The relationship between measurement and number is a potential inter-conceptual relationship. Teaching a concept is expected to connect previously learned concepts and the new concept (Bingölbali & Coşkun, 2016). In an assessment process conducted for selection purposes, solving the problem can increase its difficulty level and the time required for a solution due to the excessive use of inter-conceptual relationships, as it requires proficiency in multiple subjects when forming a solution path. When examining the possible solutions in the items from the past two years, it is observed that there are fewer items in the dimension of association between different representations of the concept compared to other dimensions. The use of various representations contributes to the development of the association skill (Bingölbali and Coşkun, 2016). However, a student with developed associative skills can effectively use different representations of the concept. Therefore, it can be expected that the number of items involving the association between different representations of the concept in the elective exam will be increased.

From the results related to the communication standard, it is observed that in both years, formal language is used more in the possible solution paths of the items compared to other types of communication. This dimension of communication, which requires understanding and using algebraic representations of formulas or mathematical definitions, indicates that operational and computational skills are necessary to solve the items. According to NCTM (2000), communication is a fundamental skill for conveying mathematical ideas in written or oral form. In problem-solving, it has not been included in the study because it is thought to be used in understanding items that are only explained in writing. The representation that students frequently use is verbal representation (İpek & Okumuş, 2012; Özaltun et al., 2013; Tanju, 2020). Due to the structure of LGS items, it is not suitable for determining verbal communication and representation. In this study, it has been determined that the most frequently used representation in the solutions is numerical. The second most usable representation was found to be images and diagrams. This result is consistent with the results of the research conducted by Özaltun et al. (2013).

Diagrams, shapes, or pictures have generally been used in the presentation of problems. This situation can be interpreted as measuring the ability to understand the given image, figure, or diagram rather than drawing an appropriate shape or diagram to solve the problem. The most commonly used representation type in 2020 and 2021 was numerical. This finding is consistent with the result that solutions require extensive formal communication. Representations aid in the development of suitable solution techniques during the problem-solving process (Kılıç, 2009). In a study conducted by Kartallıoğlu (2005), it was found that problems that could not be resolved initially could be solved correctly when revisited with the aid of shapes. Therefore, this situation can be interpreted as indicating that the prevalence of representations in LGS items may support the problem-solving process and the utilization of various strategies.

Considering all results, it is evident that the solutions to the items posed every two years correspond with the sub-dimensions of process skills and constitute well-structured, meticulously developed qualitative items that encompass a range of different skills. It has been determined that these items serve to predict the five core skills addressed in the study. The presentation and assessment of classroom activities at the national level are not feasible. However, research has indicated that the existing curriculum and textbooks are inadequate in relation to these standards. It is expected that the current textbooks, curriculum, and classroom instruction align with these central examination items or, at the very least, support the core skills being measured.

Suggestions

When the study was conducted, items were prepared based on the 2018 MoNE Curriculum. Upon examining MoNE (2024), it has been observed that the areas of skills the program aims to develop are mathematical reasoning, mathematical problem solving, mathematical representation, working with data and data-based decision making, and working with mathematical tools and technology. When examining the content of the skill of working with data and data-based decision-making, its similarity to problem-solving skills has been noteworthy. Additionally, mathematical reasoning and mathematical communication have not been defined as core skills. In the explanations of the themes fulfilled in the units of the program, there is interdisciplinary and inter-skill correlation. A comparison of central exam items may be conducted in the future due to program differences.

The exam items prepared for the LGS should encompass all foundational learning areas and be developed with a homogeneous distribution. Although the purpose of central exams is to place students in quality schools, they also provide insight into the achievement levels of participating students. The examined LGS mathematics items appear to be aimed not only at assessing knowledge but also at applying the knowledge that has been taught, with reminders provided in some items. To support students' ability to apply what they have learned, the topics in the current MDÖP can be streamlined, with a greater emphasis placed on practical application lessons. This approach will not only help in acquiring conceptual knowledge but also allow for more time to be allocated to the application phase of concepts, thus facilitating the effective use of learned knowledge.

A literature review reveals that the studies examined have been limited to analyzing mathematics items in exams according to Bloom's Taxonomy, Revised Bloom's Taxonomy, the MATH Taxonomy, curriculum gains, or learning areas. The aim of central examinations is to select and place students in educational institutions within the country; however, these exams are one of the factors that impact students' learning tendencies. Therefore, analyzing exam items in accordance with the process standards set by NCTM, the world's largest mathematics education organization, and preparing items that align with these standards is crucial for elevating central exams to an international level.

The limitation of this study is that only a two-year period was included in the study. According to process standards, the study only examined exam items from 2020 and 2021. This situation limited the ability to see the results from a broader perspective. Since the first year of LGS, exams conducted over the years can be analyzed collectively according to process standards, and comparisons can be made between years. In addition, math items from other years can be analyzed according to different skills.

Math items from exams conducted before 2018, such as TEOG and SBS, can also be analyzed and compared according to process skills. Finally, it is recommended that studies be conducted to reveal the relationship between math success in the LGS exam and process skills by year.

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