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Research Article

A correlational evaluation between students' mathematics literacy and high school entrance exam results

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On the basis of the results obtained from the high school entrance exam (HSEE) and mathematical literacy tests, this study examined the relationship between HSEE mathematics questions and mathematical literacy. A total of 120 students participated in the study. Data collection instruments consisted of mathematical literacy questions that had been validated in the literature previously. Data collection procedures were conducted in classrooms by mathematics teachers. To analyze the relationships between the data, the Kolmogorov-Smirnov test was first performed, followed by Spearman's rank difference correlation coefficient. Results showed a significant positive correlation between students' mathematics achievement and their mathematical literacy. Second, students' HSEE scores and mathematical literacy were significantly correlated. Based on the strong correlation between these variables, the preparation process for HSEE should include 21st-century skills, which are both influenced by and contribute to mathematical literacy. The objectives of secondary and high school mathematics curricula should include mathematical literacy, and teachers should be trained on how to improve students' mathematical literacy, as well as integrating teaching activities into mathematics curricula based on the relationship identified in this study.

Keywords: Correlation, high school entrance exam, high stake tests, mathematics literacy

1. Introduction

The objectives of mathematics teaching and the studies in the literature emphasize the necessity for the mathematics learned at school to be strongly reflected in students' lives. This requirement is expected to be reflected both in the content of HSEE and similar exams that measure the level of achievement of the objectives of mathematics teaching and in the results obtained by students from these exams. This expectation has led researchers to qualitative studies examining the extent to which the content of these exams is related to mathematical literacy, but no study has been found to examine the relationship between HSEE results and mathematical literacy. In addition, the studies conducted in this context in the literature (Ekinci & Bal, 2019; Kablan & Bozkuş, 2021; Öztürk & Masal, 2020; Ünal & Eroğlu, 2021) revealed different results about the relationship between HSEE content and mathematics literacy. This situation shows that there is a need for studies that will both bring together different qualitative results and provide quantitative representations of the relationship by focusing on the results as well as the content. Accordingly, this study first examines the relationship between HSEE and mathematical literacy frameworks and then presents quantitative values representing the direction and strength of this relationship.

HSEE is an assessment tool for eighth-grade students transitioning to secondary education in Turkey. In the HSEE, students are presented with a total of 90 multiple-choice questions, comprising 40 quantitative and 50 verbal questions. Among them, twenty questions pertain to mathematics, covering five learning areas in the secondary school curriculum (Ministry of National Education [MoNE], 2018). These learning areas involve numbers and operations, algebra, geometry and measurement, data processing, and probability. These learning areas also align with the mathematical content categories defined as quantity, change and relationships, space and

shape, uncertainty, and data in the mathematical literacy framework used in the Programme for International Student Assessment [PISA] applications organized by the OECD.

PISA has been conducted every three years since 2000. However, due to the pandemic, PISA 2021 was carried out in 2022. This assessment includes test items and various questionnaires covering mathematical literacy, science literacy, reading skills, problem-solving, and financial literacy. In each application, one of these areas- mathematical literacy, science literacy, and reading skills- is designated as the primary focus. Specifically, reading skills were the focus in 2000, mathematics in 2003, and science in 2006, with the same implementation cycle. Turkey has consistently participated in PISA since 2003. PISA evaluates the level of basic knowledge and skills necessary for 15-year-old students to thrive in modern society (MoNE, 2012). This age group corresponds to eighth-grade students in Turkey. Hence, both PISA and HSEE samples share similar characteristics in this regard.

Mathematical literacy is defined as an individual's ability to formulate, use, and interpret mathematics across various contexts (OECD, 2016). This capacity involves mathematical reasoning, using mathematical concepts, operations, facts, and tools to describe, explain, and predict events (OECD, 2013), which helps individuals recognize the critical role of mathematics in the world and equips them to make well-informed judgments and decisions, contributing to their roles as constructive, engaged, and thoughtful citizens (OECD, 2019). It is well-known that mathematical literacy has a prominent position in the objectives outlined in Turkey's 2013 and 2018 secondary school mathematics curricula (MoNE, 2013; 2018).

The above explanations and evaluations regarding HSEE, the secondary school mathematics curriculum [SSMC], and mathematical literacy offer an essential insight into the intersections among these three points. In essence, they arise from the similarities between the PISA and HSEE samples, the alignment of mathematical contents within the mathematical literacy framework with the learning areas measured in the HSEE (especially in the context of mathematics questions), and the incorporation of mathematical literacy as an objective within the HSEE. The relationship between the samples is evident, but further elaboration is needed to move beyond awareness and to provide a comprehensive evaluation of the other two mentioned connections.

1.1. Learning Areas and Mathematical Content Categories

The evaluations in this section are based on the content presented in MoNE (2018) and OECD (2018). The first assessment discusses the relationship between the mathematical content outlined in the mathematical literacy framework and the learning domains measured in the HSEE through mathematics questions.

Numbers and Operations & Quantity: This learning domain encompasses the following sub-learning areas: natural numbers, fractions, decimals, percentages, integers, rational numbers and the four operations as well as the exponents and radicals, factors and multiples, sets, ratio, and proportion. The quantitative mathematical content category presented in the framework of mathematical literacy focuses on understanding number systems and their algebraic properties, the basic concept of numbers, nested number systems (e.g., from natural numbers to integers, rationals to reals), arithmetic operations, and algebraic properties of number systems. The numbers themselves are of partial importance; the operations performed using them make them a powerful tool. Both scopes encompass the same sets of numbers and the four operations associated with them.

Algebra & Change and Relationships: This learning domain covers the sub-learning areas of algebraic expressions, equations, linear equations, identities, and inequalities. Within the mathematical content category of change and relationships presented within the framework of mathematical literacy, the traditional mathematical concepts related to functions and algebra, including algebraic expressions, equations, inequalities, and their representation through tables and graphs, are used to define, model, and interpret change.

Geometry and Measurement & Space and Shape: This learning domain involves the sub-learning areas such as basic geometric concepts and drawings, triangles, quadrilaterals, polygons,

geometric objects, angles, lines, circle and circle, transformation geometry, perspective, congruence and similarity, length, time, area and liquid measurement. Additionally, the coordinate system introduced in the linear equations sub-learning area of the algebra is applied effectively within the geometry and measurement learning domain. Space and shape patterns involve properties, position, orientation, representation of objects, analysis of visual information, comprehension of perspective, map reading and drawing, and the application of technology for shape transformations. Geometry has a primary function for the mathematical content category of space and shape presented within the framework of mathematical literacy. This category relies on elements of other mathematical domains, such as measurement and algebra, as well as the learning domain of geometry and measurement.

Data Processing and Probability & Uncertainty and Data: These domains encompass sub-learning areas such as data collection and evaluation, data analysis, and probability of simple events. The mathematical content category of uncertainty and data, as presented within the framework of mathematical literacy, covers data collection, data analysis, data presentation, probability, and inference with a similar scope.

The assessments outlined above show a significant overlap between the mathematical contents suggested within the mathematical literacy framework and the learning domains measured in the HSEE (particularly in mathematics questions). However, the mathematical contents discussed above represent only one of the three dimensions of mathematical literacy. The other two dimensions are context and mathematical processes. Therefore, the relational assessments presented above are limited to the mathematical content dimension of mathematical literacy.

1.2. Secondary School Mathematics Curriculum and Mathematical Literacy

The second assessment discusses the relationship between the objectives of the SSMC (MoNE, 2018) and mathematical literacy. The first objective of the SSMC aims to enable students to develop and effectively use their mathematical literacy skills, with the term “mathematical literacy” directly included. The second objective of the SSMC aims to help students understand mathematical concepts and apply them in daily life. Berberoğlu and Kalender (2005) suggest that mathematical literacy assessments measure not just what is taught in schools but also how effectively this knowledge can be applied in real-life situations. The resemblance between this statement and the second objective is an important indicator of the relationship between the two. Moreover, the definition of mathematical literacy as "an individual's capacity to formulate, use, and interpret mathematics in a variety of contexts" (OECD, 2016) emphasizes the significance of the term "context," which highlights those mathematical questions are embedded in real-life situations (Altun, 2016). The third objective of the SSMC aims to enable students to express their thoughts and reasoning easily in the problem-solving process and to identify gaps in the mathematical reasoning of others. This objective also encompasses critical thinking. It is worth noting that the PISA 2022 mathematical literacy framework is centered around a problem-solving cycle, with mathematical reasoning playing a central role in this framework. Furthermore, the inclusion of critical thinking as one of the eight 21st-century skills in the PISA 2022 framework is significant. These skills serve as the development basis for mathematical literacy (OECD, 2018), and this inclusion underlines the connection between the third objective of the SSMC and mathematical literacy. In addition to the relational assessments made for each objective, there are other indicators of the relationship between multiple SSMC goals and mathematical literacy. For instance, mathematical literacy aims to assess one’s ability to apply mathematical reasoning and solve problem skills across various 21st-century contexts (OECD, 2018), which is associated with both the second and third objectives of the SSMC.

The first three objectives of the SSMC were chosen for this analysis because they clearly demonstrate the relationship between SSMC and mathematical literacy. Although the ranking of objectives in terms of importance is not specified, these first objectives have a broader scope than the other ones.

1.3. Literature Review

Öztürk and Masal (2020) examined HSEE mathematics questions for the years 2018 and 2019, focusing on mathematics literacy proficiency levels. According to OECD (2018) sources, these proficiency levels are categorized from the lowest level 1 to the highest level 6. They revealed that the HSEE mathematics questions were primarily within the second proficiency level; there were no questions at the fifth and sixth proficiency levels in 2018, and only one question at the fifth level was included in 2019. No question could be qualified at the sixth proficiency level. These findings indicate that HSEE mathematics questions did not cover all mathematical literacy proficiency levels during these years. It should be noted that the mathematical literacy proficiency levels are based on the processes individuals follow during problem-solving and the skills required for these processes (OECD, 2009). Therefore, the results of Öztürk and Masal's study (2020) reduce the strength of the relationship between HSEE mathematics questions and mathematical literacy.

In their study, Ünal and Eroğlu (2021) examined the alignment between the HSEE mathematics questions for the years 2018, 2019, and 2020 and the objectives outlined in the SSMC. They revealed that many HSEE mathematics questions were framed within fictional contexts, while questions with real-life contexts were in the minority. This finding can be seen as evidence that weakens the strength of the relationship between the second objective of SSMC - to enable students to understand mathematical concepts and apply them in daily life - and HSEE mathematics questions. The second objective of the SSMC is closely related to mathematical literacy, emphasizing the inclusion of real-world situations. Therefore, as mentioned above, it can also be considered evidence that weakens the strength of the relationship between HSEE mathematics questions and mathematical literacy.

Kablan and Bozkuş (2021) assessed HSEE mathematics questions used since 2018, focusing on teachers' perspectives on the HSEE mathematics questions. Their findings suggested that these questions were closely related to everyday life. Accordingly, contrary to Ünal and Eroğlu's (2021) conclusion, teachers provided evidence for the strong relationship between the second objective of SSMC and HSEE mathematics questions. Ekinci and Bal (2019) also confirmed that 2018 HSEE mathematics questions were related to daily life, but no information was shared about the number of these questions.

1.4. The Aim

In the existing literature, qualitative studies have yielded varying results about the strength of the relationship between HSEE mathematics questions and mathematics literacy. These inconsistencies have highlighted the necessity for a quantitative evaluation to complement qualitative findings. Accordingly, this study aimed to explain the relationship between HSEE mathematics questions and mathematical literacy based on the results obtained by students from HSEE and mathematical literacy tests. We sought answers to the following research questions:

RQ 1) Is there a statistically significant relationship between the number of mathematics questions students answered correctly in 2023 HSEE and the number of questions they answered correctly in the mathematics literacy test?

RQ 2) Is there a statistically significant relationship between students' 2023 HSEE scores and the number of questions they answered correctly in the mathematics literacy test?

Although the first research question was answered based on the number of HSEE mathematics questions answered correctly by the students, the second research question could be answered based on students' total HSEE scores. The HSEE scores encompass various subjects, and no specific score represents only the mathematics achievement of the students in the HSEE, which was a limitation of this study. Therefore, the answer to the first research question serves as a stronger indicator of the relationship examined in this study. In contrast, the answer to the second research question can be considered complementary evidence supporting the overall findings.

2. Method

2.1. Research Model and Sampling

The method employed in this study, which seeks to describe the relationship between Students' HSEE mathematics achievement and mathematical literacy achievement through a sample representing the entire universe, falls under the category of a correlational survey model. The correlational survey model aims to determine the existence and/or degree of co-variation between two or more variables (Karasar, 2009).

The purposive sampling method was used to select the participants. Purposive sampling, which allows in-depth research to be conducted by selecting information-rich situations, is preferred when it is desired to study one or more specific situations that meet certain criteria or have certain characteristics. The researcher tries to understand natural and social events or phenomena in the context of the selected situations and to discover and explain the relationships between them (Büyüköztürk et al., 2012). Depending on the purpose of this study, the sample was formed from eighth-grade students. In addition, schools with different types and locations were included in the study in order to represent the universe more.

The sample comprised 120 eighth-grade students at the time of the study. Table 1 provides information about students' gender, the type of school they attend, and the location of their schools.

Table 1
Information about the participants

Variable	*N*	*%*
Gender		
Female	74	62
Male	46	38
School Type		
Public	84	70
Private	36	30
School Location		
Province Centre	95	79
District Centre	11	9
Village	14	12
Total	120	100

2.2. Data Collection Tools

The study has three distinct data groups: the number of mathematics questions that students answered correctly in the 2023 HSEE, their 2023 HSEE scores, and the number of questions they answered correctly in the mathematics literacy test. The first two data groups were directly extracted from the 2023 HSEE results. The third data group was obtained by administering an eight-question mathematical literacy test prepared by selecting mathematical literacy questions previously analyzed for validity in the literature (Demir, 2023). Regarding test validity, three criteria were considered in question selection: mathematical content categories, discrimination indices, and question difficulty. The data related to the test questions selected based on these criteria are shown in Table 2.

Two questions from each mathematical content category were incorporated into the test to ensure content validity. According to Crocker and Algina (1986), questions with a discrimination index of 0.30 or greater ($r_{jx} \geq 0.3$) are considered suitable for inclusion in the test without modification. All the questions in the test meet this criterion. Başol (2019) suggests that the item difficulty level of test questions should generally be at a moderate level. The average item

Table 2
Data related to the test questions

Question	*Discrimination Index (r_{jx})*	*Item Difficulty (p_j)*	*Mathematical Content Category*
1	0.44	0.73	Quantity
2	0.38	0.33	Quantity
3	0.46	0.33	Change and Relationships
4	0.49	0.75	Change and Relationships
5	0.46	0.35	Space and Shape
6	0.44	0.61	Space and Shape
7	0.51	0.76	Uncertainty and Data
8	0.38	0.34	Uncertainty and Data

difficulty value (p_j) of test questions was 0.525, indicating that the mathematics literacy test also met this requirement. The reliability coefficient (KR-20) of the test obtained from this study is 0.72. Several factors were considered in determining the total number of questions in the test (8), such as the number of mathematical literacy questions that eighth-grade students could solve within one lesson hour, exam administration, and paper distribution and collection.

2.3. Data Collection Process

The data were collected during the spring term of the 2022-2023 academic year. To enhance the validity and reliability of the data collection process, the procedures were carried out by the mathematics teachers of the participating students within their own classrooms.

2.4. Data Analysis Process

The first step in the data analysis involved assessing whether the number of HSEE mathematics questions answered correctly, HSEE scores, and the number of questions answered correctly in the mathematics literacy test were normally distributed. The results of the Kolmogorov-Smirnov test (Altunışık et al., 2007) showed that all three data groups were not normally distributed (n=120; p <.05). Therefore, Spearman's rank difference correlation coefficient was selected to analyze the relationships between them.

3. Findings

In this section and subsequent sections of the study, the number of questions students answered correctly in the tests is referred to as "Students' HSEE Mathematics Achievement" and "Students' Mathematics Literacy Achievement". Accordingly, descriptive information about the HSEE mathematics achievement, HSEE scores, and mathematics literacy achievement of the research group is shown in Table 3.

Table 3
Descriptive information on data

Variable	*N*	*Mean*	*SD*	*Min-Max Value*
HSEE Mathematics Achievement	120	8.61	7.25	0.00-20.00
HSEE Score	120	348.12	93.83	183.86-500.00
Mathematics Literacy Achievement	120	4.78	2.08	0.00-8.00

Consistent with the first research problem, the results of the correlation analysis on the relationship between students' mathematics achievement in 2023 HSEE and their mathematical literacy achievement are presented in Table 4.

Table 4
Correlation analysis results on the relationship between HSEE mathematics and mathematical literacy achievement (n=120)

	1	*2*
1. HSEE Mathematics Achievement	1	
2. Mathematics Literacy Achievement	.73**	1

Note. **The correlation is significant at p <.01 level.

As seen in Table 4, there is a statistically significant, positive, high-level relationship between HSEE mathematics and mathematics literacy achievement ($\rho = .73$; p <.01) (Büyüköztürk, 2011).

In line with the second research problem, the results of the correlation analysis examining the relationship between students' HSEE scores and their mathematical literacy achievement are presented in Table 5.

Table 5
Correlation analysis results on the relationship between students' HSEE scores and mathematical literacy achievements (n=120)

	1	*2*
1. HSEE Score	1	
2. Mathematics Literacy Achievement	.73**	1

Note. **The correlation is significant at p <.01 level.

Table 5 presents a statistically significant, positive, high-level relationship between students' HSEE scores and mathematical literacy achievement ($\rho = .73$; p <.01) (Büyüköztürk, 2011).

4. Discussion, Conclusion and Recommendations

The study has two unique results. The first result of this study shows a significant, high-level, positive relationship between students' HSEE mathematics achievement and mathematics literacy. The second result indicates a similar positive, high-level, and statistically significant relationship between students' HSEE scores and mathematical literacy. Accordingly, students with strong mathematical literacy are more likely to achieve better results in both HSEE mathematics and general assessments than their peers. It can be inferred that educational stakeholders' efforts to improve students' mathematical literacy considerably positively affect students' HSEE achievement. Conversely, neglecting to enhance students' mathematical literacy may have a detrimental impact on students' HSEE achievement. Therefore, the strong correlation between these variables proves the importance of incorporating 21st-century skills, which mathematical literacy both relies on and fosters, into the HSEE preparation process.

The first result of the study uncovers a statistically significant, high-level, positive correspondence between the relational qualitative inferences made in the introduction section of this study, which are based on the content of the relevant variables presented in MoNE (2018) and OECD (2018; 2019) sources. In this sense, it is suggested to move beyond merely emphasizing mathematical literacy as an objective in (secondary and middle school) mathematics curricula; teachers should be trained to nurture students' mathematical literacy, and teaching activities should be integrated into mathematics curricula in alignment with the level of relationship identified in this study.

It is expected that the qualitative evidence in the literature, which either weakens (Öztürk & Masal, 2020; Ünal & Eroğlu, 2021) or strengthens (Kablan & Bozkuş, 2021) the relationship between students' HSEE mathematics achievement and mathematics literacy will manifest in the strength of the relationship presented in the first result of this study. From this perspective, the first result of this study can be considered a representation where the findings of relevant qualitative studies in the literature are consolidated and examined quantitatively.

HSEE scores, examined within the scope of the second research problem, serve as an indicator that encompasses students' academic performance in various subjects. In the first result of this study, students' mathematical literacy was found to be highly and positively correlated with their HSEE mathematics achievement. This alignment with the literature, which suggests a positive relationship between students' mathematics achievement and their performance in other subjects indirectly (based on the idea of transitivity), implies the possibility of a positive relationship between achievement in other subjects and mathematics literacy. This conclusion aligns with the second result of this study. In light of this, it can be inferred that the findings from previous studies in the literature (Akay, 2004; Güleç & Alkış, 2003; Huntley, 1998; Pala & Başıbüyük, 2019; Pang & Good, 2000; Vural, 2003; Yakıcı, 1994) that assert a positive relationship between students' mathematics achievement and their achievement in other courses support the second result of this study.

If data on the specific mathematics questions that students answer correctly or incorrectly in HSEE become accessible, more detailed relational studies can be conducted. Such studies have the potential to determine the specific direction and level of the relationship between each learning domain and various mathematical content categories.

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