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Evaluation of 7th Grade Students' Mathematical Literacy Skills According to PISA Framework


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Abstract

The aim of this study is to reveal the mathematical literacy skills of seventh grade students according to the PISA Mathematical Literacy Framework. In the study, a special case study from qualitative research methods was used. The participants of the study were 25 seventh grade students studying in the middle school of a public school in Giresun province in the 2022-2023 academic year. 'Mathematical Literacy Test' was used as a data collection tool. The data obtained from the analysis were evaluated in accordance with the scoring of PISA questions and subjected to descriptive analysis. As a result of the analysis, it was concluded that the content area in which seventh grade students were most successful was the uncertainty and data area, and the mathematical process with the highest performance was the formulation process. While solving the mathematical literacy questions, it was determined that the students were successful in representation skill, reasoning and showing evidence skills, which are among the basic mathematical skills.

Keywords: Basic Mathematical Skill, Mathematical Content Areas, Mathematical Literacy, Mathematical Processes, PISA

Introduction

Mathematics, based on measurements and numbers, which emerged with the need to produce solutions to the problems encountered by human beings in order to sustain their lives, producing, developing, being open to innovations and being intertwined with life, has been one of the basic building blocks of mental thinking as it has been encountered in every field of life from history to the present day (Kabael, 2019). When we look at the developments in the 21st century, we see that knowledge, science and technology are developing very rapidly and the necessity of an innovative education has gained importance in order for people to keep up with these developments. Mathematics education aims to raise individuals who can use the knowledge learned effectively in daily life, who can produce solutions to real life problems, who have the desire to learn mathematics for this purpose, and who are aware that mathematics is a part of daily life (Doruk, 2010). Raising individuals who can produce practical solutions to daily life problems should be one of the important goals of mathematics education and educators. In line with this purpose, the need to raise individuals with mathematical literacy skills brings the need for mathematical literacy education to the forefront.

Mathematical literacy is the level of people's ability to produce constructive, explanatory and quick solutions in real life problem situations. In 2013, the Organisation for Economic Co-operation and Development (OECD) stated that

mathematical literacy is useful for the decision-making and solution-generating process that interested and thinking people need by realising the role of mathematics in the world. The need for mathematically literate individuals is increasing day by day and this need has attracted more attention in Turkey, especially in recent years.

In the PISA assessment, which started in 2000 for the first time and is carried out every three years, mathematical literacy was evaluated as the predominant area in 2003 and 2012. Turkey has been participating in the PISA assessment since 2003. When the results of Turkey's PISA assessment are analysed, it is seen that the country average increased from 2003 to 2015, but there was a decline in 2015, and even the result obtained in 2015 was lower than 2003. While this change increases the awareness of mathematical literacy in Turkey, it reveals the necessity of raising mathematically literate individuals and the fact that mathematics should be presented in the context of daily life.

When the studies on mathematical literacy are examined, it is seen that the studies mostly focus on whether the mathematical literacy education given to the students increases the mathematical literacy levels of the students ([Taşkın, 2017](#); [Köysüren, 2018](#); [Karakaş, 2019](#); [Mayan, 2019](#); [Söylemez, 2022](#); [Erişen, 2022](#)). It was found that there were a limited number of studies that addressed the difficulties encountered by students in solving mathematical literacy questions, whether they had problems in answering mathematical literacy questions, or in which content areas or in which processes they showed higher performance by analysing their answers to the questions ([Muyo, 2015](#); [Yıldız, 2019](#); [Türkan, 2019](#); [Bedir & Bal, 2020](#)). Some of the studies carried out are as follows: [Dağdelen \(2022\)](#) to examine secondary school students' mathematics anxiety and mathematics literacy self-efficacy in terms of various variables, [Akıllı \(2020\)](#) to determine the effect of mathematics literacy education on epistemological belief level, [Eroğlu Karataş \(2022\)](#) the aim of this study was to reveal the effect of the pair-focused teaching model on the mathematical literacy of 5th grade students. This study focuses on determining in which content areas and in which processes students are more successful and the skills

they use when answering mathematical literacy questions. In this context, this study is expected to make significant contributions to the literature.

Aim

The research aims to analyse the answers given by seventh grade students to the questions prepared to determine mathematical literacy and to reveal the mathematical literacy skills of students according to the PISA mathematical literacy framework.

Within the scope of the study, the following questions were tried to be answered.

- In the context of the questions in the mathematical literacy test, how are the mathematical literacy skills of 7th grade students according to mathematical content areas?
- In the context of the questions in the mathematical literacy test, how are the mathematical literacy skills of 7th grade students according to mathematical processes?
- Which mathematical skills under mathematical processes do 7th grade students have in solving the questions in the mathematical literacy test?

Method

This study aims to evaluate the mathematical literacy skills of seventh grade students according to the PISA mathematical literacy framework and to reveal the way they follow in solving mathematical literacy questions. The study was designed in accordance with the case study, which is one of the qualitative research methods. Qualitative research is a process that addresses a problem based on assumptions and includes the examination of appropriate research problems, examining people or places in their natural habitats to collect problem-based data, and reaching the final result and contributing to the literature ([Creswell, 2023](#)). Case studies are original studies that analyse a person, situation or group in depth, rather than experimental studies in which data are obtained through complex statistical analyses ([Seggie & Bayyurt, 2017](#)).

Participants

The study group of this research consists of 25 students studying in the 7th grade of a secondary school in Giresun city centre in the 2022-2023

academic year. The selection of the school was influenced by the fact that it consisted of participants that the researcher could easily reach and carry out the study. The reason why the participants determined according to the purposive sampling method are 7th grade students is that they are suitable for the PISA sample as an age group and the central exam questions for transition to high schools that they will face in the next academic year consist of similar questions. According to the purposive sampling method, firstly, the population suitable for the research is determined and then a limited number of groups are selected to represent the population ([Güler et al., 2015](#)).

Data Collection Tool

'Mathematical Literacy Test' prepared in accordance with the research questions was used as a data collection tool in the study.

The questions in the mathematics literacy test were developed by the researcher by making use of the questions published as examples from PISA 2012 main application and PISA 2012 pilot application questions and in accordance with the 7th grade curriculum. In order to determine whether the questions were intended to measure mathematical literacy and whether they were suitable for the 7th grade level, the opinions of 3 Mathematics education experts and 2 Mathematics teachers were consulted. As a result of the expert opinions, one of the questions was completely removed from the data collection tool and one of the sub-questions of one question was corrected. In order to test the language and expression rules and the comprehensibility of the questions, necessary corrections were made by taking the opinions of Turkish teachers. As a result of the expert opinions, the final form of the Mathematics literacy test was given.

The pilot application of the questions in the data collection tool was carried out with 9 7th grade students. Before the pilot application, the students were given information about mathematical literacy and mathematical literacy and sample questions were shown. The data obtained as a result of the pilot application were analysed and preliminary information about the data to be obtained from the actual application was obtained. According to the questions received from the students during the pilot

application process, the missing and incorrect parts of the data collection tool were edited and the data collection tool was finalised.

Data Analysis

The data obtained from the research were analysed in accordance with descriptive analysis in the context of the PISA 2012 mathematical literacy framework. According to descriptive analysis, the data obtained in the research are analysed and interpreted according to the themes previously found in the literature ([Yıldırım & Şimşek, 2016](#)).

Students' responses to the mathematical literacy questions were analysed in detail and each item was marked as 'true', 'false' or 'blank' as in the PISA assessment. as 'mathematical content and mathematical processes'. Mathematical content and mathematical processes were analysed according to the scores obtained by the students. Mathematical skills that emerged under mathematical processes were determined by analysing student responses in detail.

The mathematical processes and the basic mathematical skills that emerged under mathematical processes were analysed independently by two people, the researcher and another expert, in separate environments. The results of the analyses were compared and the questions on which there was disagreement were re-examined and the analysis of the data was completed. The data obtained as a result of the analysis are presented in the findings section with percentages and frequencies. In order to support the analysis of the basic mathematical skills used in mathematical processes, student responses are also presented in the findings section as raw data.

Validity and Reliability

In order to ensure the validity of the study, the participants were informed before the application that the data collected would be used for scientific purposes and kept confidential, and that codes would be used instead of their names, and the credibility of the research was strengthened.

In order to ensure the reliability of the research, the questions in the data collection tool were presented to the participants in a clear and understandable way and the expected objectives were clearly stated with

the statements such as ‘Justify your answers, explain, write your process steps ...’ in the continuation of the questions. During the development process of the data collection tool, it was tried to provide data diversification by utilising different sources. The answers obtained from the participants were presented directly as raw data in the findings section without any interpretation. In the analysis of the data, the PISA mathematical literacy framework, which was prepared in advance and explained in detail, was used and the data obtained were analysed by the researcher and another person according to the conceptual framework and the results were compared. The consistency of the findings obtained

as a result of the analyses increased the reliability of the study.

Findings

Findings Related to the First Sub-Problem

In this section, the findings related to the question ‘How are the mathematical literacy skills of seventh grade students according to mathematical content areas in the context of PISA mathematical literacy framework?’ are presented.

The number of questions answered correctly by the students are presented in Table 1 with percentage and frequency values.

Table 1 Findings Related to Mathematical Content Areas

Question	Mathematical Content Areas							
	Quantitative		Uncertainty and data		Change and relationships		Space and shape	
	f	%	f	%	f	%	f	%
Grain Production 3	20	80						
Cologne	17	68						
Apartment for Rent 2	8	32						
Car Maintenance 2	9	36						
Paragliding 1	20	80						
Dice Throw 2	18	72						
Exam Score 1	4	16						
Exam Score 2	4	16						
Grain Production 1			25	100				
Grain Production 2			18	72				
Apartment for Rent 1			23	92				
Dice Throw 1					20	80		
Social Media					17	68		
Paragliding 2					10	40		
Car Maintenance 1					13	52		
Apartment Plan 1							11	44
Apartment Plan 2							8	32

When Table 1 is analysed, the most correctly answered questions were Grain Production 3 and Paragliding 1, while Exam Score 1 and Exam Score 2 were the least correctly answered questions. Among the questions belonging to the content area of uncertainty and data, Grain Production 1 was answered correctly by all students, while Grain Production 2 was the question that students answered the least correctly. Among the questions

prepared to measure the content area of change and relationships, the most correctly answered question was Dice Throw 1, while the most correctly answered question in the content area of space and shape was Circle Plan 1.

Findings Related to the Second Sub-Problem

In this section, the findings related to the question ‘How are the mathematical literacy skills of seventh

grade students according to mathematical processes in the context of the PISA mathematical literacy framework?’ are presented. The number of questions answered correctly by the students are presented in Table 2 with percentage and frequency values.

Table 2 Findings Related to Mathematical Processes

Question	Mathematical Processes					
	Formulating		Process of Operationalising		Interpretation and evaluating	
	f	%	f	%	f	%
Cologne	17	68				
Paragliding 1	20	80				
Paragliding 2	10	40				
Dice Throw 1	20	80				
Grain Production 3			20	80		
Dice Throw 2			18	72		
Apartment Plan 1			11	44		
Apartment Plan 2			8	32		
Grain Production 1					25	100
Grain Production 2					18	72
Apartment for Rent 1					23	92
Apartment for Rent 2					8	32
Car Maintenance 1					13	52
Car Maintenance 2					9	36
Social Media					17	68
Exam Score 1					4	16
Exam Score 2					4	16

According to Table 2, the questions that the students answered most correctly in the formulation process were Paragliding 1 and Dice Throw 1, while Paragliding 2 was the least correctly answered question. It is seen that the question with the highest number of correct answers in the process of operationalising is the question on Grain Production 3 and the lowest number of correct answers is the question on Apartment Plan 2. Among the questions related to the interpretation and evaluation process, Grain Production 1 question was answered correctly by all students, while Exam Score 1 and Exam Score 2 questions were the least correctly answered questions.

Findings Related to the Third Sub-Problem

In this section, the data obtained in relation to the question ‘Which mathematical skills emerging under mathematical processes do seventh grade students have in solving mathematical literacy questions?’

are given by being supported with direct student responses. Participants were coded as O1, O2, ..., O25.

Examples of Questions in which Reasoning and Showing Evidence Skills are Used

Grain Production 3 and Paragliding 1 are questions that require the use of reasoning and evidence. Examples of the questions are given in Figures 1 and 2.

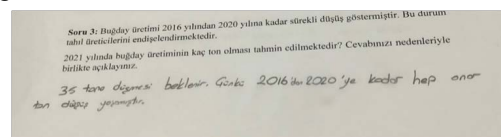


Figure 1 Example of the Correct Answer of Student O13 Coded Student for the Grain Production 3 Question

When the answer of the student coded O13 was examined, it was seen that he made the correct inference from the graph by estimating that there was

a decrease of 10 tonnes each year compared to the previous year and used the reasoning and showing skill correctly by justifying his answer.

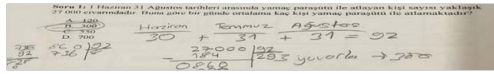


Figure 2 Example of the Correct Answer of Student Coded O25 for Paragliding 1 Question

When the answer of the student coded O25 is analysed, it is seen that he found the total number of days 92 by taking the months in accordance with the number of days in the calendar. He rounded the result to the nearest hundredth to reach the correct answer. When the operations and explanations made by the student were examined, it was seen that he reached the result with correct reasoning and supported his solution by showing evidence.

Findings Related to the Questions in which Representation Skill Emerged

Grain Production 1 and Social Media questions require the use of representation skills. Examples of correct answers to the questions are shown below.

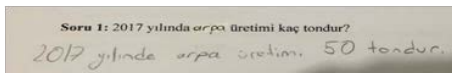


Figure 3 Example of the Correct Answer of Student Coded O9 for the Grain Production 1 Question

When the student papers were analysed, it was seen that Grain Production 1 was a question that students answered without difficulty. As seen in Figure 3, the student coded O9 reached the correct result by looking at the column graph given in the question.

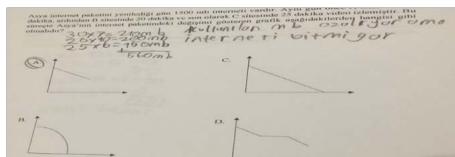


Figure 4 Example of the Correct Answer of Student Coded O23 for the Social Media Question

When Figure 4 is analysed, the student coded O23 used representation skill in the interpretation process by comparing different graphs given in the options.

Findings Related to the Questions on Communication Skills

Grain Production 2 and Car Maintenance 1 questions are the questions where communication skills are revealed. Examples of correct answers to the questions are given below.

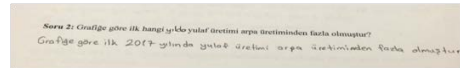


Figure 5 Example of the Correct Answer of Student Coded O21 for the Grain Production 2 Question

When the response of the student coded O21 was analysed, it was seen that he made the correct inference by looking at the graph. The student used his/her communication skills by associating the first statement in the question with the graphic representation and interpreted the question correctly.

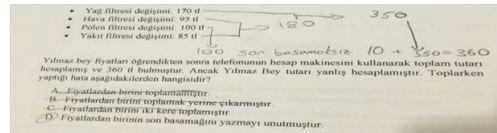


Figure 6 Example of the Correct Answer of Student O8 Coded Student for the Car Maintenance 1 Question

When the answer of the student coded O8 is analysed, the fact that he/she tried each of the options and reached the result by elimination method shows that he/she used his/her communication skill successfully.

Findings Related to the Questions in which Mathematization Skill Emerged

Cologne, Car maintenance 2 and Paragliding 2 questions are questions in which mathematization skills were used. Examples of correct answers to the questions are given below.

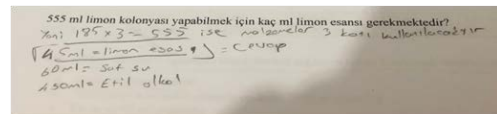


Figure 7 Example of the Correct Answer of Student O17 Coded Student for the Cologne Question

When the answer of student coded O17 in the figure is examined, it is seen that he noticed the proportion between the data presented in the real-

life problem and transferred it correctly to the desired situation. It can be said that the student was successful in mathematisation skills because he reached the expected result by making the correct inference from the given situation.

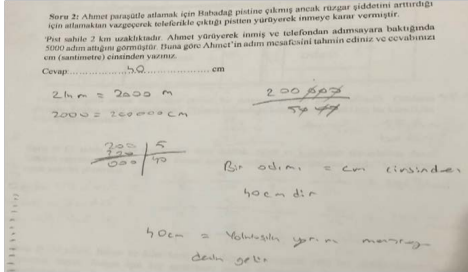


Figure 8 Example of the Correct Answer of Student Coded O11 for the Paragliding 2 Question

The student made the correct conversion between the units of length measurement and reached the correct result with the operations. It was observed that the student was successful in the mathematisation skill in the formulation process.

Discussion and Conclusion

The results of the study in which the mathematical literacy skills of seventh grade students were evaluated according to the PISA mathematical literacy framework are compared with the studies in the literature and given in this section.

In the first sub-problem of the study, seventh grade students' mathematical literacy skills were evaluated according to the mathematical content areas and according to the results obtained, the mathematical content area in which the students were most successful was the uncertainty and data content area, followed by the change and relationships content area. These areas were followed by quantitative content and space and shape content, respectively.

According to the results obtained in the PISA 2012 assessment, the average scores of the participating countries according to their mathematical literacy performance on the basis of mathematical content areas are as follows: change and relationships 488, uncertainty and data 487, quantitative 484, space and shape 482 points, and the average score of Turkey in the exam is as follows: change and relationships 448, uncertainty and data 447, space and shape 443, quantitative 442 points (MEB, 2015). It is seen that

the average of Turkey and the general average of the participating countries are similar. In this study, it was concluded that the areas in which seventh grade students showed high performance in mathematical content areas were uncertainty and data and change and relationships, while the areas in which seventh grade students showed the least success were space and shape and quantitative. When the results were analysed, it was seen that the PISA assessment results and the results of the research were similar.

In the second sub-problem of the study, seventh grade students' mathematical literacy skills were evaluated according to mathematical processes and according to the results obtained, the mathematical process in which the students were most successful was the formulating process. The second most successful process was the process of utilisation, while the least successful mathematical process was the process of interpretation and evaluation.

According to the results of the 2012 PISA assessment, the average performance scores of the participating countries according to mathematical processes are as follows: formulating 485, process of operationalising 486, interpreting 491 points; Turkey's averages are formulating 449, process of operationalising 448 and interpreting 446 points (MEB, 2015). According to the results of PISA 2012, it is seen that the highest performance is in the interpretation process and the lowest performance is in the formulating process according to the average scores of all participating countries. When we look at the averages of Turkey, it can be said that the highest performance belongs to the formulating process, while the lowest performance was shown in the interpretation process, but the averages are close to each other. The results obtained in the research differ from the average scores of all participant countries, but are in parallel with the average scores of Turkey. Because according to the results of the research, the highest performance was obtained in the formulating process, followed by the process of operationalising and the interpretation process, respectively. Again, as in the PISA results, the results obtained from this study show that the average performances according to mathematical processes are close to each other. This may be due to the fact that the number of questions belonging to the interpretation and

evaluation process is higher than the other processes and the item variety is less.

In the third sub-problem of the study, the mathematical skills used by seventh grade students under mathematical processes in solving mathematical literacy questions were evaluated. It was concluded that the skills frequently used by the students in solving mathematical literacy questions were reasoning and showing skills, representation skills, mathematisation skills and communication skills.

[Erişen \(2022\)](#) examined the effect of mathematical literacy education given to 4th grade students on students' mathematical literacy achievement and concluded that 4th grade students were more successful in the content area of uncertainty and data, but had difficulty in the area of quantitative. It was determined that the results of this study were in parallel with the result that the students were successful in the content area of uncertainty and data, but had difficulty in the area of quantitative.

[Wijaya et al. \(2015\)](#) analysed the errors in solving context-based PISA mathematical literacy questions and found that students had difficulty in transforming a real life problem into a mathematical problem. This process is a process that requires formulation skills and it was observed that students had difficulty in formulation skills. This study does not coincide with this result.

[Türkan \(2019\)](#) examined the mathematical literacy skills of 8th grade students and concluded that the most successful content area was uncertainty and data, and the mathematical process with the highest performance was the interpretation process. It is seen that this study is similar to this study according to the mathematical content areas and the basic mathematical skills used and differentiates according to the mathematical processes.

[Susanta et al. \(2022\)](#) concluded that students had difficulty in using representation skills as a result of the study they conducted to define mathematical literacy skills in the problem solving process. In this study, it was found that the students were quite successful in representation skills and they were not similar to this result.

[Kabael and Barak \(2016\)](#) examined the development of mathematical literacy of pre-

service mathematics teachers through some PISA questions in a two-stage study with 22 pre-service teachers. According to the results of the first phase, they found that pre-service teachers had difficulty in mathematisation skills, especially in graph interpretation and determining the relationships between variables. The difficulties of pre-service teachers in mathematisation skills are similar to the results of this study conducted with 7th grade students, but different results were obtained in graph interpretation and determining the relationship between variables. The fact that different results were obtained is thought to be due to the different study group.

[Özbaş \(2023\)](#) examined the relationship between mathematical representation skills and mathematical literacy in the problem solving process of 8th grade students. In his study, it is seen that the results obtained that there is a positive relationship between mathematical representation skills and mathematical literacy, but the transfer between representations is low, do not overlap with the results obtained in this study that 7th grade students are successful in representation skills.

[Runtu et al. \(2023\)](#) analysed the mathematical literacy skills of students in their study on solving mathematical literacy problems using ethnomathematical context and according to the results obtained, they found that high level students showed high success in the formulating process, medium level students had above average success, and low level students showed very little success in the formulating process.

Suggestions

Research can be conducted with different grade levels and larger study groups to measure mathematical literacy skills.

It is necessary to increase the awareness of secondary school students about mathematical literacy questions and the solution of mathematical literacy questions. For this reason, mathematical literacy trainings can be given to students and mathematics teachers to increase their awareness.

This research was conducted with a limited number of participants using qualitative research method. Experimental research can be conducted with larger sample groups.

Mathematical literacy questions consist of questions similar to the problems that individuals may encounter in their daily lives. In order to facilitate students' integration of mathematics into daily life, mathematical literacy questions can be used actively in the teaching process.

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