International Journal of Curriculum and Instructional Studies
13*(1),* 2023, 224-248
www.ijocis.com

Investigation of the Learning Outcomes of the 2018 Middle School Mathematics Curriculum in Terms of Mathematical Communication Skills[3]

Emine Tuğçe Öztaş, Ministry of Education, tuce_aksy@hotmail.com, 0000 0002-2736-8126
Nihal Tunca Güçlü, Dumlupınar University, nihal.tunca@dpu.edu.tr , 0000 0002-8512-7478

Keywords
Mathematical
Communication skills
Mathematics curriculum
Learning outcomes

Article Info:
Received : 07-06-2022
Accepted : 15-05-2023
Published : 22-06-2023

DOI: *1*0.31704/ijocis.2023.010

Abstract

Mathematics includes elements of thinking and communication skills that are essential in a changing world. In this context, thinking and communication skills have a privileged place in the mathematics curriculum (Umay, 2004). This study aims to investigate the learning outcomes of the 2018 middle school mathematics curriculum in terms of mathematical communication skills. The current study employed the document analysis research method. The document analyzed in the study consists of the learning outcomes set in the middle school 5th-8th grade mathematics curriculum, which was updated in the 2018 school year by the Ministry of National Education and is still being implemented. In the study, the researchers developed a "Mathematical Communication Skills Rubric" to examine the learning outcomes set in the middle school 5th-8th grade mathematics curriculum regarding mathematical communication skills. The analysis of the data was carried out with the deductive content analysis approach. In the study, when the learning outcomes in the middle school mathematics curriculum were examined in terms of mathematical communication skills, it was determined that 70% of the total 275 learning outcomes were insufficient. The results show that the learning outcomes of the middle school mathematics curriculum should be rearranged to serve the improvement of mathematical communication skills and that mathematical communication should be structured in more detail regarding the reading, listening, speaking and writing dimensions.

To cite this article: Öztaş, E. T., & Tunca-Güçlü, N. (2023). Investigation of the learning outcomes of the 2018 middle school mathematics curriculum in terms of mathematical communication skills. *International Journal of Curriculum and Instructional Studies*, *13*(1), 224-248. https://doi.org/10.31704/ijocis.2023.010

[3]This article was produced from the master's thesis "Examination of Middle School Mathematics Curriculum in Terms of Mathematical Communication Skills".

Introduction

Mathematics includes elements of thinking and communication skills that are essential in a changing world. In this context, thinking and communication skills have a privileged place in the mathematics curriculum (Umay, 2004). When the mathematics curriculum was examined, communication skills were emphasized for the first time in the 2005 mathematics curriculum. The emphasis on the relevant skill increased in the 2013 curriculum. The mathematics curriculum was restructured in 2018 based on the skills determined by the Turkish Competences Framework. It is seen that there is a 27% increase in the field of communication skills in the general objectives of the 2018 curriculum (Uysal & İncikabı, 2018). Mathematical communication skills dimensions are included in the general goals of the 2018 mathematics curriculum. The dimensions of mathematical communication skills are expressed in the 2018 mathematics curriculum as follows: "Understanding mathematical concepts, using mathematical concepts in daily life, expressing their thoughts and reasoning easily in the problem-solving process, perceiving the deficiencies or gaps in the mathematical reasoning of others, using mathematical terminology and language correctly, expressing concepts with different forms of representation" (MoNE, 2018, s.9). Mathematical communication skill is the ability to use mathematical language clearly and convincingly in verbal and written expression of thoughts (National Council of Teachers of Mathematics [NCTM], 2000). Mathematical communication enables students to make connections between different representations of mathematics (between the language and symbols of mathematics). As may be seen in Table 1, mathematical communication skills have four main dimensions: reading, speaking, listening and writing (Thompson & Chappell, 2007).

Table 1

Mathematical Communication Skills Dimensions

Mathematical reading	Understanding the context and putting what is read into action, such as solving verbal problems, creating and interpreting graphics, answering open-ended and multiple-choice questions (Adams & Lowery, 2007).
Mathematical speaking	Explaining and justifying their solutions, associating their thoughts with others' explanations, and arranging them when necessary (Lo & Wheatley, 1994).
Mathematical listening	The primary purpose of listening is to evaluate the accuracy of what is said. Listening reproduces one's own, the teacher's, or canonical thinking. Opens up opportunities for hearing and responding by seeking to understand another's thinking through communication; focuses on seeking information and responding to it. Listening reproduces the speaker's thinking. (For example, "Could you say more about that?" "Can you say that in another way?") (Hintz & Tyson, 2015).
Mathematical writing	Writing one's mathematical ideas about mathematical concepts, definitions and problems; writing to explain the relationships between problems, concepts and definitions; writing about constructing arguments or other students' reasoning; writing math problems; writing their original solutions to problems; writing about mathematical structures or patterns (Bell & Bell, 1985; Miller, 1990; Van de Walle, Karp & Bay-Williams, 2014).

It is necessary and important to transform the targeted skills into learning outcomes in the curriculum to make them functional and to observe and evaluate their accomplishment. Thus, evaluating the curriculum learning outcomes aiming at the improvement of mathematical communication skills and their interaction with the other dimensions of the curriculum is of great importance to yield insights into the harmony among the elements of the mathematics curriculum. Studies on the learning outcomes of the 2018 mathematics curriculum show that the learning outcomes are mostly related to the cognitive domain, and the learning outcomes addressing higher-order skills in the curriculum are limited in number (Diker-Coşkun, 2017). Parallel to the results of these studies, the exams monitoring and assessing the mathematical competency level of students in different contexts also show that the skills aimed to be imparted to students by the mathematics curriculum cannot be mastered at a sufficient level (MoNE, 2019). For example, the PISA 2018 report shows the lowest mathematical proficiency score in the middle school type in Türkiye. In addition, with reference to the results of TIMMS 2019, in which 4th grade and 8th grade students participated, it is seen that the 8th grade score in mathematics in our country is lower than the 4th grade level and below the international average (Düşkün & Korlu, 2021). Within the scope of the Monitoring and Evaluation of Academic Skills Project aims to evaluate the students' high-level skills (MoNE, 2019). When the 2018 results are examined, 3% of the 8th grade students in the mathematics test are at the advanced proficiency level and 53% at the sub-basic and basic levels. Based on the skills included in advanced mathematical competence, it is seen that only 3% of 8th grade students have the skills to make decisions, show reasons/validation, solve original problems, pose/construct problems and produce/synthesize an original product/model (MoNE, 2019). These exam results are related to the mathematical communication skill levels of the students. Therefore, it is seen that only 3% of the students have reached advanced mathematical communication competence. Because mathematical communication skills cannot be considered without some of the higher-order thinking skills:

- from problem-solving skills in terms of sharing mathematical reasoning and reasons (Sfard, 2008);
- from modeling in terms of students' expressing concepts and problem-solving processes with different forms of representation, and thus their ability to relate (Zawojevski & Lesh, 2003);
- from critical thinking skills in terms of evaluating others' mathematical ideas, deficiencies in their reasoning and reasoning strategies, and organizing their ideas (Sfard, 2008);
- from metacognitive thinking skills in terms of using comprehension control strategies appropriately while interpreting or writing mathematical expressions, questions and images (Ernest, 1987);
- mathematical original ideas, expressions, tasks and creating explanations (Zwicky, 2008) cannot be considered independent of creative thinking skills.

Given the results of the national and international exams, which confirm each other and in which mathematical competencies are determined, there is a need to examine whether the middle school mathematics curriculum learning outcomes serve the function of developing mathematical communication skills. In line with this requirement, this study aims to investigate the learning outcomes of the 2018 middle school mathematics curriculum in terms of mathematical communication skills.

It is thought that the analysis results will indicate the extent to which the middle school mathematics curriculum is suitable for reflection on the mathematical communication skills emphasized in the goals of the curriculum. The research is limited to the learning outcomes of the middle school mathematics curriculum developed in 2018. Examining the learning outcomes regarding mathematical communication skills is limited to the rubric developed by the researchers.

Method

Research Design

The current study employed the document analysis research method. As a research method, document analysis is particularly applicable to qualitative case studies—intensive studies producing detailed descriptions of a single phenomenon, event, organization, or program (Yıldırım & Şimşek, 2006). This study used this method to investigate the learning outcomes of the 2018 middle school mathematics curriculum through the indicators of mathematical communication skills. In this study, the document analysis stages identified by Forster (1994) were adopted: 1. Accessing documents, 2. Checking the originality of documents, 3. Understanding documents 4. Analyzing the data. 5. Using data (as cited in Yıldırım & Şimşek, 2006).

Accessing Documents

The document analyzed in the study consists of the learning outcomes set in the middle school 5th-8th grade mathematics curriculum, which was updated in the 2018 school year by the Ministry of National Education and is still being implemented. The 2018 middle school mathematics curriculum was accessed from the official website of the Ministry of National Education (http://mufredat.meb.gov.tr).

Checking the Originality of Documents

The document used in the research is the middle school 5-8 mathematics curriculum. Evidence for the originality of the document used in the research is given below. The process of developing the mathematics curriculum, in which documents were used in the research, is as follows (MoNE, 2018):

- It has been prepared based on "General Objectives of Turkish National Education" and "Basic Principles of Turkish National Education" expressed in Article 2 of the Basic Law of National Education No. 1739.
- It has been prepared by the General Directorate of Basic Education within the Ministry of National Education, considering the program improvement processes.
- It is the official program put into practice in the 2017-2018 academic year in Türkiye. Therefore, the document is original.

Understanding Documents

When the learning outcomes of the middle school mathematics curriculum are examined, it is seen that there are 56 learning outcomes in the 5th grade mathematics curriculum, 59 in the 6th grade, 48 in the 7th grade, and 52 in the 8th grade. There are 215 learning outcomes in the middle school mathematics curriculum. When a preliminary analysis was conducted on

215 learning outcomes set in the 5th-8th grade mathematics curriculum regarding their structural features, it was determined that some learning outcomes contain more than one action. For example, "M.8.1.1.1. Finds positive integer factors of given positive integers, writes the prime factors of positive integers as the product of exponential expressions." (MoNE, 2018) learning outcome includes two action statements. Therefore, the learning outcome is structurally divided as follows: 1. "Finds positive integer factors of given positive integers", 2. Writes the prime factors of positive integers as the product of exponential expressions. In order to make the analyzes more qualified, the researchers structurally separated 60 learning outcomes containing more than one action statement, in line with the principles of goal writing. Thus, 275 learning outcomes were analyzed.

Analyzing the Data

When the literature was examined, it was determined that the indicators of mathematical communication skills were not determined. "Mathematical Communication Skills Rubric" was developed by the researchers to examine the learning outcomes, which is the aim of the research, in terms of mathematical communication skills. As a result of the review of the literature on mathematical communication skills, it was determined that mathematical communication skills have five dimensions which are "Reading", "Speaking", "Listening", "Writing" and "Effective use of the language of mathematics" (Ernest, 1987; Hubbard, 1990; Kabael & Ata Baran, 2016; MoNE, 2018; NCTM, 2000) and then dimensions were written to reflect mathematical language skills for each dimension. In order to determine the content validity of the 23-item rubric, the data collection tool was submitted to the review of two experts from the field of mathematics education and three experts from the field of curriculum and instruction. The experts were asked to evaluate each item in the rubric regarding its clarity-comprehensibility and whether it is an indicator/ dimension of the relevant dimension. The experts stated that items of the dimension "Effective use of the language of mathematics" overlap with the items of the other dimensions (Sample items: 1. Using the symbols and terms of mathematics effectively, 2. Using mathematical language effectively in different disciplines, 3. Using mathematical language effectively in life, 4. Problem posing (asking questions), and thus, it was suggested that the items under the dimension of "Effective use of the language of mathematics" could be written under the other related items. As a result of the feedback from the experts, the dimension of "Effective use of the language of mathematics" was removed from the rubric, its items were written under the relevant dimensions and two items similar to each other were also removed from the rubric. As a result, the rubric consists of 21 items and four dimensions.

The analysis of the data was carried out with the deductive content analysis approach. In this context, the researchers in the current study prepared a "Mathematical Communication Skills Rubric" (See Appendix 1). In this context, mathematical communication skills were conceptually understood due to the literature review and four dimensions, namely reading, speaking, listening and writing, were determined. Each dimension was divided into items arranged in line with expert feedback. The lowest 21 and the highest 105 points are taken from the rubric. The rubric is of the interval scale type. In the data analysis process, the learning outcomes of the middle school 5th-8th grade mathematics curriculum were coded as insufficient (1), partially sufficient (2), moderately sufficient (3), largely sufficient (4) and

sufficient (5). Their level of reflection mathematical communication skills was evaluated key to the below-given score ranges.

- 21-37: Insufficient
- 38-54: Partially Sufficient
- 55-71: Moderately Sufficient
- 72-88: Largely Sufficient
- 89-105: Sufficient

Mathematics learners need to perform mathematical thinking to make sense of mathematics. As mathematical communication reveals mathematical ideas (Lo & Wheatley, 1994; Sfard, 2008), all learning outcomes should be geared towards mathematical communication skills. For this reason, all learning outcomes are expected to be aimed at mathematical communication skills. For this reason, the word "absent" is not included in the rubric. The rubric uses "insufficient" instead of "absent".

The learning outcomes were analyzed altogether with their explanations. The rubric components were graded by considering what the outcome wanted to express directly and together with the explanations. Therefore, M.8.1.1.1 is divided considering its explanation in the learning outcome curriculum: 1. "Finds positive integer factors of given positive integers", 2. Writes the prime factors of positive integers as the product of exponential expressions). After examining the learning outcome structurally and observing that it contains a single action statement, it was examined in terms of the dimensions of mathematical communication skills. While examining the learning outcome in terms of dimensions, it was determined which dimension or dimensions were focused on in the learning outcome. For example, "Writes the prime factors of positive integers as the product of exponential expressions" learning outcome involves the act of “writing”. It is considered to be directly related to the “writing” dimension of mathematical communication skills. It is not possible to organize the learning environment in which this learning outcome, which focuses on the act of writing, is handled without reading, listening or speaking. For this reason, the phrase "insufficient" was used instead of "none" in the rubric. Since it requires primarily computational skill (use of prime multiplier algorithm or multiplier tree method) and conceptual understanding (the concept of prime factor), it was coded as sufficient (5) concerning the dimension of “writing/using mathematical terminology (concepts and symbols) appropriately and correctly” of the “writing” dimension of mathematical communication skills. It was coded as insufficient (1) in the other dimension and items. As a result, the total score of 25 was reached by analyzing it over the 21 items. Because the obtained 25 value is in the insufficient range (21-37 Insufficient), the learning outcome “M.8.1.1.1. Writes the prime factors of positive integers as the product of exponential expressions.” was determined to be insufficient in terms of mathematical communication skills. Table 2, the coding of this sample learning outcome is shown.

Table 2

Coding of a Sample Learning Outcome (M.8.1.1.1) Over the Mathematical Communication Skills Rubric

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	**1**	2	3	4	5
	Interpreting mathematical expressions, questions, ideas, tasks, or images	**1**	2	3	4	5
	Making sense of what they have read by making connections with their previous knowledge and experiences	**1**	2	3	4	5
	Determining mathematical reading strategies suitable for the purpose	**1**	2	3	4	5
	Using comprehension control strategies	**1**	2	3	4	5
Speaking	Using appropriate and correct mathematical language/ expressions when expressing mathematical thoughts;	**1**	2	3	4	5
	Sharing mathematical reasoning and justifications;	**1**	2	3	4	5
	Making statements that evaluate the mathematical thinking of others;	**1**	2	3	4	5
	Using mathematical expressions to make sense of the relationships between people and objects and the relationships of objects with each other;	**1**	2	3	4	5
Listening	Organizing mathematical ideas by discussing them with others	**1**	2	3	4	5
	Correctly understanding speech about mathematics;	**1**	2	3	4	5
	Seeing the deficiencies in the mathematical reasoning of others and evaluating the mathematical thinking and strategies of others;	**1**	2	3	4	5
	Constructing new knowledge and meanings by associating new ideas with existing ones;	**1**	2	3	4	5
	Making sense of the relationships between people and objects and the relationships of objects with each other by using the language of mathematics	**1**	2	3	4	5
Writing	Expressing/sharing mathematical ideas in writing using the language of mathematics;	**1**	2	3	4	5
	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions;	**1**	2	3	4	5
	Properly expressing mathematical ideas in writing with different representations;	**1**	2	3	4	5
	While expressing mathematical ideas in writing, using mathematical language to make sense of the relationships between people and objects and the relationships of objects with each other;	**1**	2	3	4	5
	Making use of strategies that will enable them to express their mathematical ideas more clearly and accurately;	**1**	2	3	4	5
	Using the mathematical writing process for different purposes	**1**	2	3	4	5
The total score of the learning outcome (M.8.1.1.1.) from the rubric/ comment			25/ Insufficient			

The analyzes of the learning outcomes were made by the researchers separately. Later, the researchers came together and agreed to analyze the learning outcomes. In addition, researchers and an expert in the relevant field (an academician who gives an expert opinion on

the creation of the rubric, who has studies on mathematics curriculum and in the field of curriculum and instruction) came together. They reviewed the analysis of all the learning outcomes together and reached a consensus on the analyses. In order to conduct the reliability study of the analyzed learning outcomes, 20% of the learning outcomes were analyzed by an expert in the field of curriculum and instruction who has studies on qualitative research. Afterward, the researcher compared their coding with the coding of the expert who did the reliability study. Afterward, the expert and the researchers came together and discussed the learning outcomes where there was a difference of opinion. The reliability of the study was calculated using the formula Reliability = Agreement / (Agreement + Disagreement) x 100, suggested by Miles and Huberman (1994). The agreement rate between the researchers was 83% and the data analysis process was completed.

Using Data

The document used in the research is the middle school mathematics curriculum developed by the Ministry of National Education and applied throughout Türkiye. In order to improve the quality of education, the most important task falls to educational institutions. All educational activities in formal education institutions are carried out within a curriculum framework. The training programs include which behaviors and how to gain an individual in the institution. Therefore, the quality of education largely depends on the curriculum implemented. In this context, it is necessary to eliminate the faults and deficiencies of the applied education programs, reorganize them in line with contemporary developments and changes, in other words, to improve the programs continuously. In this context, the study is thought to contribute to developing mathematics programs.

Results

Under the title of findings, the frequency distribution of the mathematical communication skills levels of the middle school mathematics curriculums' learning outcomes in accordance with the grade levels and the examples of mathematics lesson learning outcomes are given.

The Reflection Level of Mathematical Communication Skills in 5th Grade Mathematics Curriculum Outcomes

Under this title, the frequency distribution of the mathematical communication skills levels of the middle school 5th grade mathematics curriculum learning outcomes are given (Table 3).

When Table 3 is examined, 66 (85.71%) of the 77 learning outcomes at the 5th grade level are insufficient, while 11 (14.79%) are partially sufficient. It was determined that there is no learning outcome moderately, largely sufficient or sufficient in terms of mathematical communication skills at the 5th grade levels. Below is an insufficient 5th grade learning outcome example regarding mathematical communication skills.

Table 3

Frequency Distributions Regarding the Mathematical Communication Skill Levels of the 5th Grade Mathematics Curriculum Outcomes

Skill Levels	*Learning Outcomes*	
	f	*%*
Insufficient	66	85.71
Partially Sufficient	11	14.29
Moderately Sufficient	0	0
Largely Sufficient	0	0
Sufficient	0	0
Total	77	100

"Performs the multiplication operation of two three-digit natural numbers at most (M.5.1.2.4.)" is a sample learning outcome found insufficient in terms of mathematical communication skills at the 5th grade level. The levels of the learning outcome (M.5.1.2.4) across the dimensions of the reading and writing of mathematical communication skills are shown in Table 3.1.

Table 3.1

The Levels of the Insufficient Learning Outcome (M.5.1.2.4.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
The total score of the learning outcome (M.5.1.2.4.) from the rubric/ comment [(19 (number of insufficient items) x1)+(2 (number of sufficient items) x5)]		29/ Insufficient				

As the learning outcome aims to enable students to understand the concept of multiplication correctly and to apply its standard rules accurately, it was determined to be sufficient in terms of the skill of reading/understanding the meaning of mathematical expressions, questions and tasks in a way that reflects the relationships between them in the reading dimension and in terms of the skill of writing mathematical concepts and symbols appropriately and correctly in the writing dimension. It was found to be insufficient in the other skills of the reading and writing dimensions. It was determined to be insufficient in all the sub-skills of the listening and speaking dimensions. As a result of the sum of the scores in all the dimensions, it was seen that the level of this learning outcome in terms of reflection on mathematical communication skills is insufficient. It was determined to be insufficient in all the sub-skills of the listening and speaking dimensions, so they are not included in the table. Below is a partially sufficient 5th grade learning outcome example in terms of mathematical communication skills.

"Solves problems that require addition and subtraction with fractions with equal denominators (M.5.1.4.2.)" is a sample learning outcome found partially sufficient regarding mathematical communication skills at the 5th grade level. The levels of the learning outcome (M.5.1.4.2) across the dimensions of the reading and writing of mathematical communication skills are shown in Table 3.2.

Table 3.2

The Levels of the Partially Sufficient Learning Outcome (M.5.1.4.2.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
	Determining mathematical reading strategies suitable for the purpose	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions;	1	2	3	4	**5**
The total score of the learning outcome (M.5.1.4.2.) from the rubric/ comment [(15 (number of insufficient items) x1)+(6 (number of sufficient items) x5)]		45/ Partially sufficient				

The learning outcome aims to apply the skills of adding and subtracting fractions in the problem situation. In this learning outcome, students are expected first to understand the problem and then transfer it to mathematical expressions. In summary, students are expected to understand the verbal expressions in the problem and the numerical relations described in the problem and to create connections between them. Therefore, for this learning outcome, in the reading dimension of the rubric, "Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them"; "Interpreting mathematical expressions, questions, ideas, tasks, or images"; "Making sense of what they have read by making connections with their previous knowledge and experiences "; The items "Determining mathematical reading strategies suitable for the purpose" were coded sufficient. In the writing dimension, the items "Writing/using mathematical terminology (concepts and symbols) appropriately and correctly", "Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions" were coded sufficiently. In all other dimensions, they were coded insufficiently.

The Reflection Level of Mathematical Communication Skills in 6th Grade Mathematics Curriculum Outcomes

Under this title, the frequency distribution of the mathematical communication skills levels of the middle school 6th grade mathematics curriculum learning outcomes are given (Table 4).

Table 4

Frequency Distributions Regarding the Mathematical Communication Skill Levels of the 6th Grade Mathematics Curriculum Outcomes

Skill Levels	*Learning Outcomes*	
	f	*%*
Insufficient	51	68.92
Partially Sufficient	23	31.08
Moderately Sufficient	0	0
Largely Sufficient	0	0
Sufficient	0	0
Total	74	100

When Table 4 is examined, 51 (68.92%) of the 74 learning outcomes at the 6th grade level are insufficient, while 23 (31.08%) are partially sufficient. It was determined that there is no learning outcome moderately, largely sufficient or sufficient in terms of reflection mathematical communication skills at the 6th grade levels. Below is an insufficient 6th grade learning outcome example in terms of mathematical communication skills.

"It explains that the number of unit cubes placed in the rectangular prism in such a way that there is no space in the volume of that object (M.6.3.4.1)" is a sample learning outcome that was found to be insufficient in terms of mathematical communication skills at the 6th grade level. The coding for the reading sub-dimension of the mathematical communication skills of the learning outcome (M.6.3.4.1) is given in Table 4.1.

Table 4.1

The Levels of the Insufficient Learning Outcome (M.6.3.4.1.) Across the Reading Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
The total score of the learning outcome (M.6.3.4.1) from the rubric/ comment [(19 (number of insufficient items) x1)+(2 (number of sufficient items) x5)]		29/ Insufficient				

This learning outcome aims to connect the concept of volume and the number of cubes placed inside the rectangular prism. The student is expected to interpret the given image and switch to the expressions that make up the concept of volume. Therefore, for this learning outcome, in the reading dimension of the rubric, "Reading mathematical expressions, questions, tasks or visuals that reflect the meanings of the concepts and the relationships between them" and "Interpreting mathematical expressions, questions, ideas, tasks or pictures" were sufficiently coded. Below is a partially sufficient 6th grade learning outcome example regarding mathematical communication skills.

"Writes an algebraic expression suitable for a verbally given situation and a verbal situation suitable for a given algebraic expression (M.6.2.1.1)" is a sample learning outcome found to be partially sufficient regarding mathematical communication skills at the 6th grade level. The levels of the learning outcome (M.6.2.1.1) across the dimensions of the reading and writing of mathematical communication skills are shown in Table 4.2.

Table 4.2

The Levels of the Partially Sufficient Learning Outcome (M.6.2.1.1.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions;	1	2	3	4	**5**
	Properly expressing mathematical ideas in writing with different representations;	1	2	3	4	**5**
	While expressing mathematical ideas in writing, using mathematical language to make sense of the relationships between people and objects and the relationships of objects with each other;	1	2	3	4	**5**
The total score of the learning outcome (M.6.2.1.1) from the rubric/ comment [(14 (number of insufficient items) x1)+(7 (number of sufficient items) x5)]		49/ Partially sufficient				

While writing an algebraic expression suitable for a given situation or writing a verbal situation suitable for an algebraic expression, first of all, in the reading dimension, students are expected to read the meanings of the concepts in the given situation as follows: to reflect the relationships between them and to use their comprehension and interpretation skills by making a connection with the prior knowledge about the order of operations for the given situation. In the writing dimension, they are expected to express their ideas in writing using mathematical language, to write concepts and symbols appropriately and accurately, to use symbols or variables accurately, to express them in writing by making transitions between different representations, and to communicate and communicate between people and objects in this process. to make sense of the interaction between objects and objects. This learning outcome, considered sufficient for target skills, is partially sufficient to gain mathematical communication skills when coded in all dimensions. Since there is no action covering the listening and speaking dimensions of mathematical communication in this learning outcome, the skill levels in these dimensions were determined as insufficient and are not listed separately in Table 4.2.

The Reflection Level of Mathematical Communication Skills in 7th Grade Mathematics Curriculum Outcomes

Under this title, the frequency distribution of the mathematical communication skills levels of the middle school 7th grade mathematics curriculum learning outcomes are given (Table 5).

Table 5

Frequency Distributions Regarding the Mathematical Communication Skill Levels of the 7th Grade Mathematics Curriculum Outcomes

Skill Levels	*Learning Outcomes*	
	f	*%*
Insufficient	42	71.19
Partially Sufficient	17	28.81
Moderately Sufficient	0	0
Largely Sufficient	0	0
Sufficient	0	0
Total	59	100

When Table 5 is examined, 42 (68.92%) of the 59 learning outcomes at the 7th grade level are insufficient, while 17 (28.81%) are partially sufficient. It was determined that there is no learning outcome moderately, largely sufficient or sufficient level in terms of reflection mathematical communication skills at the 7th grade levels. Below is an insufficient 7th grade learning outcome example in terms of mathematical communication skills.

"Examines its properties by determining the congruent angles, reverse angles, interior reverse angles, and exterior reverse angles formed by a sac. (M.7.3.1.2)" is a sample learning outcome found to be insufficient in terms of mathematical communication skills at the 7th grade level. The coding for the reading dimension of the mathematical communication skills of the learning outcome (M.7.3.1.2) is given in Table 5.1.

Table 5.1

The Levels of the Insufficient Learning Outcome (M.7.3.1.2.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
The total score of the learning outcome (M.7.3.1.2) from the rubric/ comment [(18 (number of insufficient items) x1)+(3 (number of sufficient items) x5)]		33/ Insufficient				

With this learning outcome, the first thing expected from students is the classification of congruent angles, reverse angles, interior reverse angles and exterior reverse angles. Then, they are expected to distinguish the features of these concepts from each other. Finally, they must use these features to select and configure instances. Therefore, for this learning outcome, in

the reading dimension of the rubric, "Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them"; "Interpreting mathematical expressions, questions, ideas, tasks, or images" and "Making sense of what they have read by making connections with their previous knowledge and experiences were coded sufficient. In all other dimensions, they were coded as insufficiently. Below is a partially sufficient 7th grade learning outcome example regarding mathematical communication skills.

"Creates the relations between the area of the rhombus and the area of the trapezoid (M.7.3.2.4.)" is a sample learning outcome found to be partially sufficient regarding mathematical communication skills at the 7th grade level. The levels of the learning outcome (M.7.3.2.4.) across the dimensions of the reading and writing of mathematical communication skills are shown in Table 5.2.

Table 5.2

The Levels of the Partially Sufficient Learning Outcome (M.7.3.2.4.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions;	1	2	3	4	**5**
	Properly expressing mathematical ideas in writing with different representations;	1	2	3	4	**5**
The total score of the learning outcome (M.7.3.2.4) from the rubric/ comment [(15 (number of insufficient items) x1)+(6 (number of sufficient items) x5)]		45/ Partially sufficient				

In this learning outcome, it is necessary to benefit from the previously learned area relations of triangle, square and rectangle in creating rhombus and trapezoid area relations. The student is expected to establish relationships between images, create new mathematical expressions, and observe the variables of the area of the rhombus and trapezoid by using these relations. Therefore, for this learning outcome, in the reading dimension of the rubric, "Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them"; "Interpreting mathematical expressions, questions, ideas, tasks, or images"; and "Making sense of what they have read by making connections with their previous knowledge and experiences " were coded sufficient. In the writing dimension, the items "Writing/using mathematical terminology (concepts and symbols) appropriately and correctly", "Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions" and "Properly expressing mathematical ideas in writing with different representations" were coded sufficient. In all other dimensions, they were coded insufficiently.

The Reflection Level of Mathematical Communication Skills in 8th Grade Mathematics Curriculum Outcomes

Under this title, the frequency distribution of the mathematical communication skills levels of the middle school 8th grade mathematics curriculum learning outcomes are given (Table 6).

Table 6

Frequency Distributions Regarding the Mathematical Communication Skill Levels of the 8th Grade Mathematics Curriculum Outcomes

Mathematical Communication Skills Levels	*Learning Outcomes*	
	f	*%*
Insufficient	32	49.23
Partially Sufficient	23	35.38
Moderately Sufficient	9	13.85
Largely Sufficient	1	1.54
Sufficient	0	0
Total	65	100

When Table 6 is examined, 32 (49.23%) of the 65 learning outcomes at the 8th grade level are insufficient, 23 (35.38%) are partially sufficient, 9 (13.85%) are moderately sufficient, and 1 (1.54%) is largely sufficient. It was determined that there is no sufficient learning outcome in terms of mathematical communication skills at the 8th grade level. Below is an insufficient 8th grade learning outcome example in terms of mathematical communication skills.

"Calculates integer powers of integers (M.8.1.2.1.)" is a sample learning outcome found to be insufficient in terms of mathematical communication skills at the 8th grade level. The coding for the reading sub-dimension of the mathematical communication skills of the learning outcome (M.8.1.2.1.) is given in Table 6.1.

Table 6.1

The Levels of the Insufficient Learning Outcome (M.8.1.2.1.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
The total score of the learning outcome (M.8.1.2.1.) from the rubric/ comment [(19 (number of insufficient items) x1)+(2 (number of sufficient items) x5)]		29/ Insufficient				

The learning outcome aims to perform the mathematical operation by following the routine steps appropriately. In this learning outcome, what is expected from students is primarily to

remember the information and determine where and when they will use it. Then they are expected to answer the question or perform the task with appropriate steps. Therefore, for this learning outcome, only the item "Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them" was coded as sufficient in the reading dimension of the rubric. In the writing dimension, "Writing/using mathematical terminology (concepts and symbols) appropriately and correctly" was coded sufficiently. In all other dimensions and items, they were coded insufficiently. Below is a partially sufficient 8th grade learning outcome example in terms of mathematical communication skills.

"Determines the relationship between the squares of positive integers and the square roots of the squares of these numbers (M.8.1.3.1.)" is a sample learning outcome regarding mathematical communication skills at the 8th grade level. The levels of the learning outcome (M.8.1.3.1.) across the dimensions of the reading and writing of mathematical communication skills are shown in Table 6.2.

Table 6.2

The Levels of the Partially Sufficient Learning Outcome (M.8.1.3.1.) Across the Reading and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
Writing	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Properly expressing mathematical ideas in writing with different representations	1	2	3	4	**5**
The total score of the learning outcome (M.8.1.3.1.) from the rubric/ comment [(15 (number of insufficient items) x1)+(5 (number of sufficient items) x5)]		41/ Partially sufficient				

This learning outcome aims to determine the relationship between a number and its square root based on the relationship between the square root, the area of the square and the side of the square. In this learning outcome, students are expected to use the conceptual meaning of the square root and show it with a different representation (area of the square and the side of the square). Then, it is expected to reach an inference (the square root of integers is taught by relating the side length of a square given its area) by establishing a relationship between the two cases. Therefore, for this learning outcome, in the reading dimension of the rubric, "Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them"; "Interpreting mathematical expressions, questions, ideas, tasks, or images"; and " Making sense of what they have read by making connections with their previous knowledge and experiences" were coded sufficient. In the writing dimension, the items "Writing/using mathematical terminology (concepts and symbols) appropriately and correctly" and "Properly expressing mathematical ideas in writing

with different representations" were coded sufficiently. In all other dimensions, they were coded insufficiently. Below is a moderately sufficient 8th grade learning outcome example in terms of mathematical communication skills.

"Explains identities with models" (M.8.2.1.3) is a sample learning outcome found to be moderately sufficient regarding mathematical communication skills at the 8th grade level. The levels of the learning outcome (M.8.2.1.3.) across the dimensions of the reading, writing and speaking of mathematical communication skills are shown in Table 6.3.

Table 6.3

The Levels of the Moderately Sufficient Learning Outcome (M.8.2.1.3.) Across the Reading Speaking and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
	Determining mathematical reading strategies suitable for the purpose	1	2	3	4	**5**
	Using comprehension control strategies	1	2	3	4	**5**
Speaking	Using appropriate and correct mathematical language/ expressions when expressing mathematical thoughts	1	2	3	4	**5**
	Sharing mathematical reasoning and justifications	1	2	3	4	**5**
Writing	Expressing/sharing mathematical ideas in writing using the language of mathematics;	1	2	3	4	**5**
	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions	1	2	3	4	**5**
	Properly expressing mathematical ideas in writing with different representations	1	2	3	4	**5**
The total score of the learning outcome (M.8.2.1.3.) from the rubric/ comment [(10 (number of insufficient items) x1)+(11 (number of sufficient items) x5)]		65/ Moderately Suffic.				

In this learning outcome, the student is expected first to make sense of the given equation (read it) and then associate and interpret the mathematical expressions with the field topic. The student is also expected to determine reading strategies and benefit from comprehension control strategies during this process. In the written and oral explanation process, the student is expected to convey his thoughts correctly and appropriately with the help of mathematical language and to reflect on the reasoning process. At the same time, the writing skills of mathematical communication will be used to show the given identities with different forms of representation and create equations suitable for the representation shown. Therefore, for this learning outcome, all items were coded sufficiently in the reading dimension of the rubric. The items "Using appropriate and correct mathematical language/ expressions when expressing

mathematical thoughts" and "Sharing mathematical reasoning and justifications" were coded sufficient in the speaking dimension. In the writing dimension, the items "Expressing/sharing mathematical ideas in writing using the language of mathematics", "Writing/using mathematical terminology (concepts and symbols) appropriately and correctly", "Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions" and "Properly expressing mathematical ideas in writing with different representations" were coded sufficient. In listening to dimension, items were coded insufficiently. Below is a largely sufficient 8th grade learning outcome example in terms of mathematical communication skills.

"Expresses how one of the two variables that have a linear relationship between them changes depending on the other with a table and equation" (M.8.2.2.3.) is a sample learning outcome found to be largely sufficient in terms of mathematical communication skills at the 8th grade level. The levels of the learning outcome (M.8.2.2.3.) across the dimensions of the reading, writing and speaking of mathematical communication skills are shown in Table 6.4.

Table 6.4

The Levels of the Largely Sufficient Learning Outcome (M.8.2.2.3.) Across the Reading Speaking and Writing Dimensions

Dimensions	*Items*	*Insufficient*	*Partially S.*	*Moderately S.*	*Largely S.*	*Sufficient*
Reading	Reading mathematical expressions, questions, tasks or images in a way that reflects the meaning of the concepts and the relationships between them	1	2	3	4	**5**
	Interpreting mathematical expressions, questions, ideas, tasks, or images	1	2	3	4	**5**
	Making sense of what they have read by making connections with their previous knowledge and experiences	1	2	3	4	**5**
	Determining mathematical reading strategies suitable for the purpose	1	2	3	4	**5**
	Using comprehension control strategies	1	2	3	4	**5**
Speaking	Using appropriate and correct mathematical language/ expressions when expressing mathematical thoughts;	1	2	3	4	**5**
	Sharing mathematical reasoning and justifications;	1	2	3	4	**5**
	Using mathematical expressions to make sense of the relationships between people and objects and the relationships of objects with each other;	1	2	3	4	**5**
Writing	Expressing/sharing mathematical ideas in writing using the language of mathematics;	1	2	3	4	**5**
	Writing/using mathematical terminology (concepts and symbols) appropriately and correctly	1	2	3	4	**5**
	Using symbols, variables and mathematical equations accurately and clearly to model mathematical ideas with mathematical expressions;	1	2	3	4	**5**
	Properly expressing mathematical ideas in writing with different representations;	1	2	3	4	**5**
	While expressing mathematical ideas in writing, using mathematical language to make sense of the relationships between people and objects and the relationships of objects with each other;	1	2	3	4	**5**

Table 6.4. *(Cont.)*

Making use of strategies that will enable them to express their mathematical ideas more clearly and accurately;	1	2	3	4	**5**
The total score of the learning outcome (M.8.2.2.3.) from the rubric/ comment [(7 (number of insufficient items) x1)+(14 (number of sufficient items) x5)]	77/ Largely Sufficient				

When analyzed, considering that the action in this learning outcome is "to express" (TDK, 2015), it is inferred that it is related to the components of reading, speaking and writing of mathematical communication. The learning outcome includes the sub-skills of reading mathematical expressions in a way that reflects the relationships between them; making sense of and interpreting what they have read by associating them with previous knowledge and experiences; analyzing/reading mathematical expressions with the awareness that he/she will create a table or graph and using comprehension control strategies in this process. While expressing what they have read in writing or orally requires sub-skills of using mathematical terminology correctly and appropriately, expressing mathematical thoughts using mathematical language, justifying mathematical ideas and making sense of mathematics by associating it with daily life. In addition to these, this learning outcome also aims to enable students to create appropriate and correct writing strategies (planning, defining the scope of the subject and deciding on its boundaries, determining and organizing the logical sequence of ideas, reviewing and checking what they have written) while expressing their thoughts in writing with tables and graphics. Along with the aforementioned sub-skills, it has been determined that the learning outcome makes the most significant contribution to mathematical communication skills.

Discussion, Conclusion and Implications

In the study, when the learning outcomes in the middle school mathematics curriculum were examined regarding mathematical communication skills, it was determined that 70% of learning outcomes were insufficient. Moreover, the relevant findings showed that the learning outcomes of the 8th grade mathematics curriculum make a greater contribution to the learning outcome of mathematical communication skills by students than the learning outcomes of the other grade levels. In addition, as the grade level increases, it was observed that the learning outcomes reflected mathematical communication skills more. This result can be explained by the fact that, due to the cumulative nature of mathematics, the formation of basic conceptual meanings occurs in the first years of middle school.

The current study's findings revealed that the learning outcomes are more concentrated on certain items of mathematical communication's reading and writing dimensions. Of course, these skills also have a significant role in developing mathematical communication skills, but they are insufficient for improving mathematical communication skills. Writing and reading skills do not only consist of using mathematical terminology appropriately and correctly, as assumed in the middle school mathematics curriculum. Writing allows the individual to restructure his/her thoughts and create individual meanings by taking control of his/her learning into his/her own hands (Emig, 1977). The middle school mathematics curriculum does not have any learning outcome to address not only this skill of reflecting thoughts, which is one of the critical points of mathematical thinking and communication but also the skills of writing for the mathematical writing process, writing about mathematics and creative writing

about mathematics (problem posing, story writing). When the learning outcomes are considered guides for other curriculum elements, it will be inevitable for middle school mathematics teachers to organize teaching situations focusing on the one-way dimension of reading and writing. This result is supported by the research findings of the study conducted by Kabael and Ata Baran (2016), indicating that middle school mathematics teachers try to impart mathematical communication skills by emphasizing the meaning of symbols, using approaches for teaching mathematical concepts and using written or reading.

Another remarkable result of the study is that the indicators for the listening and speaking dimensions of mathematical communication are included in the learning outcome set in the middle school mathematics curriculum at a meager rate compared to the other dimensions. It has been determined that there are implicit expressions for listening in the action statements of some learning outcomes. However, there are no learning outcomes directly aiming at the improving of listening skills. Parallel to the result obtained in the current study, Özpınar and Arslan (2017) also found that middle school mathematics teachers emphasized understanding mathematical expressions, explaining symbols in writing, writing symbols correctly and appropriately, and addressing the listening dimension indirectly.

The results show that the learning outcomes of the middle school mathematics curriculum should be rearranged to serve the improving of mathematical communication skills and that mathematical communication should be structured in more detail regarding the reading, listening, speaking and writing dimensions.

Author Contributions

This article was produced from the master's thesis "Examination of Middle School Mathematics Curriculum in Terms of Mathematical Communication Skills. The authors contributed equally to the conversion of the thesis into an article.

References

Adams, T. L., & Lowery, R. M. (2007). An analysis of children's strategies for reading mathematics. *Reading & Writing Quarterly: Overcoming Learning Difficulties, 23*(2), 161-177. https://doi.org/10.1080/10573560601158479

Bell, E. S., & Bell, R. N. (1985). Writing and mathematical problem solving: arguments in favor of synthesis. *School Science and Mathematics*, *85*(3), 210–221. https://doi.org/10.1111/j.1949-8594.1985.tb09614.x.

Diker Coşkun, Y. (2017). *Öğretim programları arka plan raporu*. http://www.academia.edu/download/55270428/Ogretim_Programlari_Arka_Plan_Raporu.pdf

Düşkün, Y., & Korlu, Ö. (2021). *Eğitim izleme raporu 2020: Eğitimin çıktıları. Eğitim Reformu Girişimi.* https://www.egitimreformugirisimi.org/egitim-izleme-raporu-2020-egitimin-ciktilari

Emig, J. A. (1977). Writing as a mode of learning. *College Composition and Communication, 28*(2), 122-128. https://files.eric.ed.gov/fulltext/ED474209.pdf

Ernest, P. (1987). A model of the cognitive meaning of mathematical expressions. *The British Journal of Educational Psychology 57*, 343-370. https://doi.org/10.1111/j.2044-8279.1987.tb00862.x

Hintz, A., & Tyson, K. (2015). Complex listening: Supporting students to listen as mathematical sense-makers. *Mathematical Thinking and Learning, 17*(4), 296-326, https://doi.org/10.1080/10986065.2015.1084850

Hubbard, R. (1990). Teaching mathematics reading and study skills. *International Journal of Mathematical Education in Science and Technology, 21*(2), 265–269. https://doi.org/10.1080/0020739900210212

Kabael, T., & Ata Baran. A. (2016). Matematik öğretmenlerinin matematiksel iletişim becerilerinin gelişimine yönelik farkındalıklarının incelenmesi. *Elementary Education Online*, *15*(3), 868-881. http://dx.doi.org/10.17051/io.2016.78518

Lo, J. J., & Wheatley, G. H. (1994). Learning opportunities and negotiating social norms in mathematics class discussion. *Educational Studies in Mathematics, 27*(2), 145-164. https://www.jstor.org/stable/3482795

Ministry of National Education (MoNE). (2018). *İlköğretim matematik dersi (1-8. Sınıflar) öğretim programı.* MoNE Publications.

Ministry of National Education (MoNE). (2019). *Akademik becerilerin izlenmesi ve değerlendirilmesi (ABİDE) 8. sınıf raporu.* MoNE Publications. http://eskisehirodm.meb.gov.tr/www/abide-2018-turkiye-raporlari/icerik/85

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. NCTM.

Özpınar, İ., & Arslan, S. (2017). Ortaokul matematik öğretmenlerinin matematiksel iletişim becerisine yönelik görüşlerinin incelenmesi. *Turkish Studies (Electronic)*, *12*(17), 337-356. http://dx.doi.org/10.7827/TurkishStudies.11930.

Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourses, and mathematizing*. Cambridge University Press.

Thompson, D. R., & Chappell, M. F. (2007). Communication and representation as elements in mathematical literacy. *Reading & Writing Quarterly, 23*(2), 179–196. https://www.tandfonline.com/loi/urwl20

Umay, A. (2004, Kasım, 6). *Matematik eğitiminde değişim*. Matematikçiler Derneği. http://www.matder.org.tr/matematik-egitiminde-degisim/

Uysal, R., & İncikabı, L. (2018). Son dönem matematik dersi öğretim programlarının genel amaçları üzerine bir araştırma. *Ondokuzmayis University Journal of Education*, *37*(1), 223-247. https://doi.org.10.7822/omuefd.358121

Yıldırım, A., & Şimşek, H. (2006). *Sosyal bilimlerde nitel arastirma yöntemleri*. Seçkin Publishing.

Zawojevski, S. J., & Lesh, R. (2003). A models and modeling perspective on problem solving. In R. Lesh & H. M. Doerr (Eds.), *Beyond constructivism: A models and modeling perspective on mathematics problem solving, learning and teaching* (pp.317-336). Lawrence Erlbaum Associates.

Zwicky, J. (2008). *The shape of content: Creative writing in mathematics and science*. CRC Press.

Uluslararası Eğitim Programları ve Öğretim Çalışmaları Dergisi
13(1), 2023, 224-248
www.ijocis.com

TÜRKÇE GENİŞ ÖZET

Ortaokul Matematik Dersi Öğrenme Kazanımlarının Matematiksel İletişim Becerileri Açısından İncelenmesi

Giriş

Matematiksel iletişim becerisi, düşüncelerin sözlü ve yazılı ifadesinde matematiksel dili açık ve inandırıcı bir şekilde kullanma becerisidir (National Council of Teachers of Mathematics [NCTM], 2000). Matematiksel iletişim, öğrencilerin matematiğin farklı temsilleri arasında (matematiğin dili ve sembolleri arasında) bağlantılar kurmasını sağlar. Matematiksel iletişim becerilerinin okuma, konuşma, dinleme ve yazma olmak üzere dört ana boyutu vardır (Thompson & Chappell, 2007).

Hedeflenen becerilerin öğretim programlarında kazanımlara dönüştürülerek işlevsel hale getirilmesi, başarılarının gözlemlenmesi ve değerlendirilmesi gerekli ve önemlidir. Bu nedenle, matematiksel iletişim becerilerinin geliştirilmesine yönelik program kazanımlarının ve bunların programın diğer bileşenleriyle etkileşiminin değerlendirilmesi, matematik öğretim programının öğeleri arasındaki uyumun anlaşılması açısından büyük önem taşımaktadır. Halihazırda uygulanmakta olan matematik öğretim programının kazanımları üzerine yapılan araştırmalar, kazanımların çoğunlukla bilişsel alanla ilgili olduğunu ve müfredatta üst düzey becerilere yönelik kazanımların sınırlı sayıda olduğunu göstermektedir (Diker-Coşkun, 2017). Bu çalışmaların sonuçlarına paralel olarak öğrencilerin matematiksel yeterlilik düzeylerini farklı bağlamlarda izleyen ve değerlendiren sınavlar da matematik öğretim programı ile öğrencilere kazandırılması amaçlanan becerilerin yeterince kazanılamayacağını göstermektedir (MEB, 2019). Örneğin PISA 2018 raporu ortaokul türünde en düşük matematik yeterlilik puanını gösteriyor. Ayrıca 4. sınıf ve 8. sınıf öğrencilerinin katıldığı TIMMS 2019 sonuçlarına göre ülkemizde 8. sınıf matematik puanının 4. sınıf seviyesinin altında ve uluslararası ortalamanın altında olduğu görülmektedir (Düşkün & Korlu, 2021). Akademik Becerileri İzleme ve Değerlendirme Projesi kapsamında öğrencilerin üst düzey zihinsel becerilerinin değerlendirilmesi amaçlanmaktadır (MEB, 2019). 2018 sonuçları incelendiğinde matematik testinde 8. sınıf öğrencilerinin %3'ü ileri yeterlilik düzeyinde, %53'ü alt temel ve temel düzeydedir. İleri matematik yeterliğinin içerdiği becerilere bakıldığında, 8. sınıf öğrencilerinin sadece %3'ünün karar verme, neden gösterme/doğrulama, orijinal problem çözme, problem kurma/kurma ve orijinal bir ürün/model üretme/sentezleme becerilerine sahip olduğu görülmektedir. (MEB, 2019). Bu sınav sonuçları öğrencilerin matematiksel iletişim beceri düzeyleri ile ilişkilidir. Matematiksel yeterliklerin belirlendiği ve birbirini doğrulayan ulusal ve uluslararası sınav sonuçları dikkate alındığında, ortaokul matematik dersi öğretim programı

kazanımlarının matematiksel iletişim becerilerini geliştirme işlevine hizmet edip etmediğinin incelenmesine gereksinim duyulmaktadır.

Bu gereksinim doğrultusunda gerçekleştirilen bu çalışmada, ortaokul matematik dersi öğretim programı kazanımlarının matematiksel iletişim becerileri açısından incelenmesi amaçlanmaktadır.

Yöntem

Araştırmada, doküman analizi yöntemi kullanılmıştır. Çalışmada ortaokul 5-8. sınıf matematik dersi öğretim programı kazanımlarının matematiksel iletişim becerileri açısından incelenebilmesi için araştırmacılar tarafından "Matematiksel İletişim Becerileri Rubriği" geliştirilmiştir. Rubrik, 21 madde ve dört boyuttan oluşmaktadır: Okuma, Yazma, Konuşma, Dinleme. Rubrik, aralık ölçeği türündedir. Verilerin analizi, tümdengelimsel içerik analizi yaklaşımı ile gerçekleştirilmiştir. Verilerin analizi sürecinde ortaokul 5-8. sınıf matematik öğretim programı kazanımları yetersiz (1), kısmen yeterli (2), orta düzeyde yeterli (3), büyük ölçüde yeterli (4) ve yeterli (5) şeklinde kodlanmıştır. Matematiksel iletişim becerilerini yansıtma düzeyleri aşağıda verilen puan aralıklarına göre değerlendirilmiştir.

- 21-37: Yetersiz
- 38-54: Kısmen Yeterli
- 55-71: Orta Derecede Yeterli
- 72-88: Büyük ölçüde Yeterli
- 89-105: Yeterli

Öğrenme kazanımların kodlama aşamasında; eylem ifadesinin öncelikle matematiksel iletişim becerilerinin hangi bileşenine yönelik olduğu belirlenmiş ardından eylem ifadesinin bilişsel beceri düzeyi belirlenerek matematiksel iletişim becerilerinin alt bileşenlerine göre kodlaması gerçekleştirilmiştir. Örneğin "M.8.1.1.1. Pozitif tam sayıların asal çarpanlarını üslü ifadelerin çarpımı şeklinde yazar." kazanımı "yazma" eylemini içermesinden dolayı doğrudan matematiksel iletişim becerilerinin yazma bileşenine yönelik olduğu görülmektedir. Daha çok işlemsel beceri (asal çarpan algoritması veya çarpan ağacı yöntemi kullanımı) ve kavramsal anlama (asal çarpan kavramı) gerektirmesinden dolayı matematiksel iletişim becerilerinin yazma bileşeninin "matematiksel terminolojiyi (kavram ve sembolleri) uygun ve doğru bir şekilde yazma/kullanma" alt bileşeni açısından yeterli (5) olarak kodlanmıştır. Diğer bileşenlerde ve alt bileşenlerinde yetersiz (1) olarak kodlanmıştır. Sonuçta 21 bileşen üzerinden analiz edilerek toplam değer olan 25'e ulaşılmıştır. Elde edilen 25 değerinin yetersiz aralığında olmasından dolayı (21-37 Yetersiz), "M.8.1.1.1. Pozitif tam sayıların asal çarpanlarını üslü ifadelerin çarpımı şeklinde yazar." kazanımı matematiksel iletişim becerilerini kazandırmaya hizmet etme düzeyi açısından yetersiz olarak belirlenmiştir.

Bulgular

5-8. sınıf matematik dersi öğrenme kazanımlarının 191'i (69.46) yetersiz düzeyde, 74'ü (%26.91) kısmen yeterli düzeyde, 9'u (%3.27) orta düzeyde yeterli, 1'i (%0.36) büyük ölçüde yeterli düzeydedir. Dolayısıyla büyük bir kısmının matematiksel iletişim becerileri açısından orta düzey ve altında bir yeterliğe sahip olduğu görülmektedir. Bu kapsamda 5. sınıf düzeyinde 77

kazanımdan 66 tanesi (%85.71) yetersiz iken, 11 tanesi (%14.79) kısmen yeterli düzeydedir. 6. sınıf düzeyinde 74 kazanımdan 51 tanesi (%68.92) yetersiz, 23 tanesi (%31.08) kısmen yeterli düzeydedir. 7.sınıf düzeyinde 59 kazanımdan 42 tanesi (%71.19) yetersiz, 17 tanesi (%28.81) kısmen yeterli düzeydedir.

Tartışma, Sonuç ve Öneriler

Araştırmada matematiksel iletişim becerileri açısından ortaokul matematik öğretim programında yer alan kazanımlar incelendiğinde toplam 275 kazanımın %70'inin yetersiz olduğu belirlenmiştir. Ayrıca elde edilen bulgular, 8. sınıf matematik öğretim programı kazanımlarının öğrencilerin matematiksel iletişim becerileri kazanımlarına diğer sınıf seviyelerindeki kazanımlara göre daha fazla katkı sağladığını göstermiştir. Ayrıca sınıf düzeyi yükseldikçe matematiksel iletişim becerilerinin kazanımlara daha fazla yansıdığı görülmüştür. Bu sonuç, matematiğin birikimli doğası gereği temel kavramsal anlamların oluşumunun ortaokulun ilk yıllarında gerçekleşmesi ile açıklanabilir.

Mevcut çalışmanın bulguları, öğrenme çıktılarının daha çok matematiksel iletişimin okuma ve yazma boyutlarının (okuma, konuşma, dinleme, yazma) belirli alt bileşenlerinde yoğunlaştığını ortaya koymuştur. Bu maddeler, "Kavramların anlamlarını ve aralarındaki ilişkileri yansıtacak şekilde matematiksel ifadeleri, soruları, görevleri veya görselleri okuma" ve "Matematiksel terminolojiyi (kavramlar ve semboller) uygun ve doğru bir şekilde yazma/kullanma" şeklindedir. Elbette bu becerilerin matematiksel iletişim becerilerinin gelişmesinde de önemli bir rolü vardır, ancak yetersizdirler.

Araştırmanın bir diğer dikkat çekici sonucu ise, matematiksel iletişimin dinleme ve konuşma boyutlarına yönelik göstergelerin diğer boyutlara göre yetersiz oranda yer almasıdır. Bazı kazanımların eylem ifadelerinde dinlemeye yönelik örtük ifadelerin olduğu tespit edilmiştir. Ancak doğrudan dinleme becerilerinin geliştirilmesini amaçlayan herhangi bir kazanım bulunmamaktadır. Bu çalışmada elde edilen sonuca paralel olarak Özpınar ve Arslan (2017) da ortaokul matematik öğretmenlerinin matematiksel ifadeleri anlamaya, yazıda sembolleri açıklamaya, sembolleri doğru ve uygun yazmaya ve dolaylı olarak dinleme boyutuna değinmeye önem verdiklerini bulmuşlardır.

Elde edilen sonuçlar, ortaokul matematik öğretim programı kazanımlarının matematiksel iletişim becerilerinin gelişimine hizmet edecek şekilde yeniden düzenlenmesi ve matematiksel iletişimin okuma, dinleme, konuşma ve yazma boyutlarına göre daha detaylı yapılandırılması gerektiğini göstermektedir.

Appendix

Matematiksel İletişim Becerileri Rubriği

Boyutlar	Maddeler	Yetersiz	Kısmen yeterli	Orta Düzeyde	Büyük ölçüde yeterli	Yeterli
Okuma	Matematiksel ifadeleri, soru, görev veya görselleri kavramların anlamını,aralarındaki ilişkileri yansıtacak şekilde okuma	1	2	3	4	5
	Matematiksel ifade, soru, fikir, görev veya görselleri yorumlama	1	2	3	4	5
	Okuduklarını önceki bilgi ve deneyimleri ile bağlantılar kurarak anlamlandırma	1	2	3	4	5
	Okuma amacını belirleme	1	2	3	4	5
	Anlama kontrol stratejileri kullanma	1	2	3	4	5
Konuşma	Matematiksel düşüncelerini ifade ederken uygun ve doğru matematiksel dil/ ifadeler kullanma	1	2	3	4	5
	Matematiksel muhakemelerini ve gerekçelendirmelerini paylaşma	1	2	3	4	5
	Başkalarının matematiksel düşüncelerini değerlendirecek ifadelerde bulunma	1	2	3	4	5
	Matematiksel ifadelerini insan ve nesneler arasındaki ilişkileri ve nesnelerin birbirleriyle ilişkilerini anlamlandırmak için kullanma	1	2	3	4	5
	Başkalarıyla tartışarak matematiksel fikirlerini düzenleme	1	2	3	4	5
Dinleme	Matematik ile ilgili konuşmaları doğru anlama	1	2	3	4	5
	Başkalarının matematiksel akıl yürütmelerindeki eksiklikleri veya boşlukları görme ve başkalarının matematiksel düşüncelerini ve stratejilerini değerlendirme	1	2	3	4	5
	Yeni düşünceler ile var olan düşünceleri ilişkilendirerek yeni bilgiler ve anlamlar inşa etme	1	2	3	4	5
	Başkaları tarafından matematiksel bir dil kullanılırken matematiğin anlam ve dilini kullanarak insan ile nesneler arasındaki ilişkileri ve nesnelerin birbirleriyle ilişkilerini anlamlandırma	1	2	3	4	5
Yazma	Matematiksel düşüncelerini matematiksel dil kullanarak yazılı ifade etme/ paylaşma	1	2	3	4	5
	Matematiksel terminolojiyi (kavram ve sembolleri) uygun ve doğru bir şekilde yazma	1	2	3	4	5
	Matematiksel düşünceleri matematiksel ifadelerle modellemek için sembol, değişken ve matematiksel denklemleri doğru ve açık şekilde kullanma	1	2	3	4	5
	Matematiksel fikirleri farklı temsillerle uygun şekilde yazılı ifade etme	1	2	3	4	5
	Matematiksel düşüncelerini yazılı ifade ederken matematiksel dil kullanarak insan ile nesneler arasındaki ilişkileri ve nesnelerin birbirleriyle ilişkilerini anlamlandırma	1	2	3	4	5
	Matematiksel düşüncelerini daha açık ve doğru yazılı ifade etmeyi sağlayacak stratejilerden yararlanma	1	2	3	4	5
	Matematiksel yazma sürecini farklı amaçlar için kullanma	1	2	3	4	5