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The Views of Primary School Teacher Nominees on the Language Applied in Teaching Mathematics

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Abstract

Teachers' effective use of mathematical language in teaching mathematics appears as a factor that certainly influences students' insight into the lesson. This research aims to investigate the views of primary school teacher nominees about the mathematical language applied in mathematics lessons and to make some recommendations for the effective use of mathematical language. This research has been organized using phenomenology research design, one of the qualitative research designs. The study group of this research consists of 12 teacher candidates who endure their education in the Department of Primary Education. The semi-structured interviews were conducted face-to-face. The data obtained was considered by descriptive analysis technique. In this context, the participants stated the mathematical language idea as a concept, symbol, graph figure, sign, number, and term. Besides, the participants listed the factors affecting the effective use of mathematical language as difficult, daily life language, time, curriculum, attitude, incomplete, and application. Finally, the participants made some recommendations such as it should be included in the curriculum, activities should be prepared, visual materials should be used, emphasis should be placed on undergraduate education, and simple, clear, and understandable language should be used to increase the effective use of mathematical language. As a result, teachers need to have the competencies to use mathematical language effectively, as it will increase the mathematical achievements of students. Hence, both pre-service and in-service training should be provided to prospective teachers and teachers to enable them to use the mathematical language effectively.

Keywords: Mathematics teaching, mathematical language, classroom teacher.

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Introduction

Language is one of the most crucial elements that people have transferred from the past to the present and ensures the development of societies. Vygotsky emphasized the relationship between ideas and language use. According to Vygotsky, language is not only a simple tool for expressing knowledge but also a basis for the formation of ideas (Schütz, 2002). Language has an important place in all areas of life for concepts such as solving problems, reasoning, ideas, and imagination (Güzel, 2014). Mathematics also holds a specific place in language, which is crucial for all languages.

Language is an element that helps students understand and express mathematics (Haylock & Cockburn, 2014). Students and teachers can better express their mathematical concepts and opinions to others using language (Brown, 2000). Mathematics is an international language with symbols and terms for all cultures and civilizations from the past to the present (Yıkmış, 2012). Mathematical language is a comprehensive set of rules that includes mathematical concepts, operations, and symbols and allows for the explanation of scientific concepts (Çalıkoğlu-Bali, 2003). Baykul (2009) defined the ability to use mathematical language as the ability to express mathematical concepts and

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the relationships between these concepts with mathematical notation, symbols, and figures. Pirie (1998) defined mathematical language as a mechanism that teachers and students use to express mathematical meanings to each other. Mathematical language is a living concept with its terminology that enables the learning of concepts, deriving new concepts when necessary (Karaçay, 2011). In line with the above definitions, mathematical language can be defined as a tool with its own symbols, terms and models that help to explain, discuss, and share scientific ideas, improve mathematical understanding, and enable communication.

Mathematics is characterized by its own language, style of expression, terms, and vocabulary. Some of these may be words used only in mathematics lessons, while others may be words used in daily life (Aydın & Yeşilyurt, 2007). Conversations involving concepts, words and symbols used in the classroom are only a part of the language of mathematics (Aiken, 1972). In addition, the instructions given to students, the sentences they express, the questions they ask, the topics discussed, and formal or informal expressions constitute a part of the language of mathematics. Children are confronted with this language throughout the day and use it without realizing it (Haylock & Cockburn, 2014). Kane (1968) states that mathematical linguistics and word order show less variability than the language used in daily life. Proper use of language is substantial in teaching mathematical concepts to students and developing mathematical thinking in students. Therefore, language plays a significant role in students' learning of concepts (Lansdell, 1999). Concepts related to mathematics vary. For example, in addition to basic concepts such as counting, addition, subtraction, multiplication, division, and numbers in mathematics, concepts such as length, volume, and weight can also be mentioned. Children begin to learn these concepts from birth by experiencing different processes and following their developmental characteristics (Yıldız, 2002).

Mathematical language is highly significant in point of enabling children to communicate, express their ideas, and explain them correctly to others (Çalıkoğlu-Bali, 2002). Gay (2008) states that students' and teachers' knowledge of the meanings and terminology of mathematical words will enable mathematical communication in the classroom. Thanks to mathematical language, it can be ensured that students can easily understand the instructions in the classroom, get away from their anxiety about the mathematics lesson and process the mathematics lesson in a fun way (Taşkın & Tuğrul, 2014). Seeing that learning mathematics is related to concepts, it is closely related to the concrete experience children have. Using symbols, such as drawing graphs, and recognizing and writing numbers, helps children learn mathematics by understanding the concepts (Akman, Yüksel & Uyanık, 2000). The mathematics curriculum states that children can express their mathematical ideas logically and share them with others by using mathematical language and terminology correctly. It is also evident that by using the meaning and language of mathematics, students can understand the connection between themselves and objects and the connections between objects and each other (MoNE, 2018). Mathematical language takes a prominent place in the development of mathematical ideas. This is because students with inadequate mathematical language proficiency have poor development of ideas (Ferrari, 2004). The acquisition and teaching of mathematical language to students is important because it positively increases students' motivation and does not bind them to rules (Schoenfeld, 1992). Students' effective use of mathematical language positively affects their academic performance (Güzel & Yılmaz, 2020; Kranda, 2008; Mercer & Sams, 2006; Yüzerler, 2013; Zeybek & Açıl, 2018). Students need to acquire the language of mathematics for the above reasons. One of the most effective ways to teach students to use mathematical language effectively is undoubtedly the effective use of this language by teachers. Çalık Uzun and Çelik (2017) state that it is only possible for students to acquire the learning objectives in the curriculum with the support of teachers. The same scholars also emphasize that students who use mathematical language and terminology correctly should be trained by teachers who can use mathematical language and terminology correctly. Açıl and Zeybek (2018) state that if mathematics teachers use mathematical language more in their classrooms, students will learn and appreciate the unique structure of mathematics and support mathematical relational learning. In this context, it is critical to determine the necessary elements and what needs to be done for not only mathematics teachers but also classroom teachers to use mathematical language effectively and accurately.

When the related literature is examined, it is seen that the studies on mathematical language generally focus on middle school students' levels or opinions of using mathematical language in subjects such as exponents, lines and angles, geometry, and algebra (Akarsu-Yakar & Yılmaz, 2017;

Çakmak, Çetin & Bektemir, 2016; Güzel & Yılmaz, 2020; Ünal, 2003; Yalvaç, 2019; Yılmaz & Türkmen, 2019; Zeybek & Açıl, 2018). Apart from these studies, there are also studies in the literature examining the use of mathematical language by pre-service teachers (Aldan Karademir & Deveci, 2019; Doğan & Güner, 2012; Emre, Sağ, Gülkılık, & Argün, 2010; Fırat & Dinçer, 2018; Pazarbaşı & Es, 2015; Yeşildere, 2007). It is seen that studies on pre-service teachers' and teachers' mathematical language use are not at a sufficient level. In addition, while the studies in the literature generally focus on pre-service teachers' mathematical language use skills, it is understood that there are not enough studies that examine their views on mathematical language in depth. For these reasons, this study was designed to reveal the views of pre-service primary school teachers on mathematical language, and it is expected to make a significant contribution to the field.

The aim of this research is to examine in depth the views of prospective teachers on the mathematical language used in mathematics courses and to put forward some suggestions to ensure the effective use of mathematical language. In line with this purpose, answers to the following questions were sought. According to the participants:

1. What is the meaning of mathematical language?
2. What are the factors affecting the effective use of mathematical language?
3. What should be done to increase the effective use of mathematical language?

Methodology

In this chapter, the research method, research design, study group, data collection and analysis, the role of the researcher, and validity and reliability have been discussed respectively.

Methodology of the Study

This study was conducted with a qualitative research approach. In this aspect, qualitative research can be explained as a method of research, which tries to reveal the meanings attributed to the phenomena and events by other individuals while dealing with the phenomena and events in their nature (Altunışık et al., 2010). In qualitative research, perceptions and events are realized in their natural environment with a realistic and holistic understanding by utilizing data collection techniques such as observation, interview, and document analysis (Yıldırım & Şimşek, 2014).

Research Design

This study, which aims to determine the views of prospective teachers on the language used in the mathematics course, was designed using the phenomenological research design, one of the qualitative research method designs. Phenomenological research is to examine human cognitive, affective, and physical states from a holistic perspective (Smith & Eatough, 2007). The phenomenological research is a type of qualitative study that examines in detail the phenomena that are frequently encountered in daily life but do not have detailed information (Yıldırım & Şimşek, 2014).

Study Group

The study group of this research was determined by a homogeneous sampling technique within the framework of the purposeful sampling method. In this context, the study group of this research consists of 12 students who continue their education in the 4th grade of the Department of Classroom Teaching, Faculty of Education, Department of Elementary Education of a state university in the 2021-2022 academic year. Affinity sampling aims to examine and investigate certain subgroups in the same situation in depth through a homogeneous and small sample (Christensen, Johnson, & Turner, 2015). Therefore, it was taken into consideration that the departments, genders, ages, and internship schools of the pre-service teachers constituting the study group were similar. Table 1 illustrates the demographic information of the prospective teachers.

Table 1
Demographic Characteristics of the Prospective Teachers Participating in the Study

Participants	Department	Gender	Age	Internship School
P1	Classroom Teaching	Female	21	Elementary School
P2	Classroom Teaching	Female	21	Elementary School
P3	Classroom Teaching	Female	21	Elementary School
P4	Classroom Teaching	Female	21	Elementary School
P5	Classroom Teaching	Female	21	Elementary School
P6	Classroom Teaching	Female	21	Elementary School
P7	Classroom Teaching	Female	21	Elementary School
P8	Classroom Teaching	Male	21	Elementary School
P9	Classroom Teaching	Male	21	Elementary School
P10	Classroom Teaching	Male	21	Elementary School
P11	Classroom Teaching	Male	21	Elementary School
P12	Classroom Teaching	Male	21	Elementary School

As seen in Table 1, 7 of the participants were female and 5 were male. All participants were studying in the Department of Classroom Teaching and their ages (21) were the same.

To prevent direct recognition of the participants, the names of the participants were coded as P1, P2, P3, ..., and P12. Some of the participant statements were utilized as quotations in the findings section to corroborate the conclusions.

Data Collection and Analysis

In the related study, the researcher utilized the interview technique to collect data. In qualitative research, the interview method is frequently used to obtain data. An interview is a method of collecting data using verbal communication methods. Even though interviews are mostly conducted face-to-face, they can also be conducted with tools that can transmit instant audio and video such as telephones and camera phones (Karasar, 2013).

It was decided to use a semi-structured interview form as a data collection tool because it has a flexible structure and consists of questions related to the solution to the research problem (Merriam, 2013). In this context, a semi-structured interview form consisting of 7 questions was created to clarify the problem of the research. During the semi-structured interview, the questions might be changed depending on how the interview went and how the participants responded. Researchers can change the order of the questions or add new ones (Çepni, 2005). During the interview, some additional questions were asked beyond the interview questions prepared in advance, provided that the purpose of the study was adhered to. These questions aimed to reach different dimensions and details of the information collected (Yıldırım & Şimşek, 2014).

In the process of formulating the interview questions, the relevant literature was reviewed, and interviews were conducted with a few teachers who had experience in the issue. An expert was consulted for the form created to determine the compatibility of the interview questions with the purpose of the research. By conducting a preliminary interview with two pre-service teachers regarding the comprehensibility of the questions, the form was restructured after getting the expert opinion and some adjustments in the phrasing of the questions were made. As a result, the interview form's final version was received.

The researcher visited the participants 3 times during the data collection process. On the first visit, the researcher explained the purpose of this study to the participants, presented the interview form she had prepared in advance, asked them to think about the questions by giving them a certain amount of time, and emphasized that she expected sincere answers. On the second visit, the researcher met the participants at a place (school, cafeteria, etc.) at and time that the participants found convenient and conducted the main interviews face-to-face. Before the interviews, the participants were asked for permission to make audio recordings, and the interviews were recorded. Before the interview questions began, the participants were asked certain demographic information (such as their gender, age, etc.). The interviews lasted an average of 30 minutes and at the end of

the interview, the data in the audio recordings were written in a Word document without any changes. The transcribed data belonging to the participants were numbered and sorted. The researcher made the third and final visit to the participants to obtain participant confirmation by showing them the written versions of the interview recordings transferred to the Word document. Thus, the researcher received participant confirmation from each participant about the interviews.

The researcher paid attention to some issues during the interview. These are:

1. To remain adherent to the purpose of this research,
2. Recording the interviews,
3. Spending more time on participants' answers than the time allocated to the interview questions,
4. To include depth for the solution of the problem being studied and
5. Avoid influencing the participants (Kvale, 1996).

The data obtained was analyzed using the descriptive analysis technique and some findings were obtained. In the descriptive analysis, the data obtained are summarized and interpreted according to predetermined themes. In the analysis carried out in this way, direct quotations are often included to express the thoughts of the interviewed or observed individuals strikingly (Altunışık et al., 2001; Yıldırım & Şimşek, 2014). The stages listed below were part of the descriptive analysis of the data in this situation:

1. Creating a Framework for Descriptive Analysis: The necessary framework for analyzing the data was determined and themes were defined according to this framework.
2. Processing the Data According to the Defined Themes: Data was organized according to the defined themes. Data that did not overlap with the defined themes were excluded from the research.
3. Defining the Findings: By defining the organized data, the data was cleaned from unnecessary repetitions. Thus, it was aimed to make the data understandable.
4. Interpretation of the Findings: The findings were explained, and the findings were expressed in the context of cause and effect relationship (Yıldırım & Şimşek, 2014).

Role of the Researcher

The researcher was appointed as a classroom teacher after graduating from Hacettepe University, Faculty of Education, Department of Classroom Teaching. The researcher, who has been working as a classroom teacher for 13 years in various institutions affiliated with the Ministry of National Education, has witnessed that teachers and students do not understand mathematical language sufficiently. To draw attention to this situation and to investigate this situation in depth, she decided to conduct this research.

Validity and Trustworthiness

A variety of methods were used to ensure validity and reliability in the analysis of the data obtained. These are as follows:

- To ensure credibility and long-term interaction with the participants, an expert review was provided, and participant confirmation was made.

- To ensure transferability, participants were identified according to the purposive sampling method and detailed descriptions were made.

- To ensure consistency, it was tried to show the necessary sensitivity in the creation of the data collection tool, the processes of obtaining the data, and the analysis of the collected data.

- To ensure confirmability, the researcher filed the interview forms used as data collection tools, protected the raw data, and archived all coding and notes made during the data analysis process (Yıldırım & Şimşek, 2014).

Findings

This study aims to examine in-depth the pre-service teachers' opinions on the use of mathematical language. The data obtained for this purpose was analyzed according to the research questions respectively. In this context, the first research question is "What is the meaning of mathematical language?". When the participants' responses to this question were analyzed, the participants defined the idea of mathematical language as; 1) Concept, 2) Symbol, 3) Graph-Shape, 4) Sign, 5) Number, and 6) Term. The findings can be seen in Table 2.

Table 2

Perceptions Regarding the Concept of Mathematical Language

No	Code	f	%	Sample Sentence
1	Concept	8	33	What is important in mathematics is the concept. Therefore, when we talk about the language of mathematics, we can talk about conceptual expression (P4).
2	Symbol	6	25	It is the symbolization of mathematical sentences (P3).
3	Graph-Shape	4	17	The transformation of a written language into a graphic form is called mathematical language. The first thing that comes to my mind with mathematical language is geometric shapes (P10).
4	Sign	3	13	When I think of mathematical language, I think of four operation signs such as +, -, x and ÷ (P1).
5	Number	2	8	There is no mathematics without numbers. Therefore, mastering the language of mathematics means using numbers skillfully (P6).
6	Term	1	4	As each science has a terminological expression, mathematical language can be considered as an expression in terms (P2).
Total		24	100	

As seen in Table 2, 33% of the participants equated mathematical language with concept, 25% with symbol, 17% with graph-shape, 13% with sign, 8% with number, and 4% with term.

The second research question is "What are the factors affecting the effective use of mathematical language?". When the answers given by the participants were analyzed, the participants identified the factors affecting mathematical language as 1) Difficult, 2) Language of Daily Life, 3) Time, 4) Curriculum, 5) Attitude, 6) Incomplete, and 7) Practice. Table 3 illustrates the findings obtained.

Table 3

Factors Affecting the use of Mathematical Language in Mathematics Lessons

No	Code	f	%	Sample Sentence
1	Difficult	11	21	I think mathematical language is more difficult to learn (P5).
2	Language of Daily Life	10	20	Terms and symbols used in mathematics lessons are used differently from daily life (P1)
3	Time	9	17	No separate time was dedicated to the use of mathematical language in mathematics lessons (P6).
4	Curriculum	8	16	Mathematics curriculum does not include terms and concepts of mathematical language as learning objectives (P9).
5	Attitude	6	12	Students have negative attitudes towards mathematics (P12).
6	Incomplete	4	8	Teachers cover mathematical language incompletely and incorrectly in their classrooms (P8).
7	Practice	3	6	Applying mathematical language is not given enough attention in the lessons (P10).
Total		51	100	

As seen in Table 3, the participants listed the factors affecting mathematical language as difficult (21%), the language of daily life (20%), time (17%), curriculum (16%), attitude (12%), incomplete (8%), and practice (4%).

The third research question is "What should be done to increase the effective use of mathematical language?". When the answers given by the participants were analyzed, the participants have made several suggestions that should be done to increase the effective use of mathematical language. These are: 1) Mathematical language should be included in the curriculum, 2) Activities should be prepared, 3) Visual materials should be used, 4) It should be emphasized in undergraduate education and 5) Accurate, clear, understandable, and simple language should be used. Table 4 provides the findings.

Table 4

Suggestions for Increasing the use of Mathematical Language

No	Code	f	%	Sample Sentence
1	Mathematical language should be included in the curriculum	10	33	In the mathematics curriculum, the concepts, signs and terms of mathematical language should be included in the program as a separate acquisition. At the beginning of each unit, the theme should be started by including the concepts of that unit (P7).
2	Activities should be prepared	8	27	Effective use of language can be increased by preparing appealing activities suitable for students' grade levels, interests, and attitudes (P11).
3	Visual materials should be used	6	20	Visual materials are a method that enables a lesson to be taught more effectively. Courses prepared by using WEB2 designs in mathematics lessons will keep students active and attentive longer (P3).
4	It should be emphasized in undergraduate education	4	13	The use of mathematical language can be given a longer and wider place, especially in the mathematics teaching course of primary school teaching students (P9).
5	Correct, clear, understandable, and simple language should be used	2	7	We should use correct, clear, understandable, and simple language when teaching mathematical concepts to students (P4).
Total		30	100	

As can be seen in Table 4, the participants offered some suggestions about what should be done to increase the effective use of mathematical language. According to that, 33% of the participants recommended that it should be included in the curriculum, 27% of the participants recommended that activities should be prepared, 20% of the participants recommended that visual materials should be used, 13% of the participants recommended that it should be emphasized in undergraduate education and 7% of the participants recommended that correct, clear, understandable, and simple language should be used.

Discussion, Conclusion, and Recommendations

Considering the data gathered from the research, the researcher concluded that the participants associated the mathematical language with the concepts of 1) Concept, 2) Symbol, 3) Graphic-Figure, 4) Sign, 5) Number, and 6) Term. When the relevant literature is examined, similarly, mathematical language has the feature of revealing people's scientific thoughts. It is defined as a set of rules in which mathematical concepts, operations, and symbols are used together (Çalıkoğlu-Bali, 2003). Mathematical language is a study of patterns and relationships, a way of thinking, and a language using defined terms and symbols (Reysi, Suydam, & Lindquist, 1995). Unlike other languages developed by society, in mathematical language words are usually structures rather than concrete objects and spoken words are symbols (Brune, 1953). Mathematics is the grammar of all symbolic systems (Black, 1993). Dur (2010), on the other hand, defined the ability to use mathematical language as forming mathematical relations using mathematical concepts, operations, and symbols, and expressing the properties of concepts appropriately and correctly. In contrast to other definitions, Pirie (1998) defined mathematical language as a mechanism that teachers and

students use to express their mathematical meanings to each other. Raiker (2002) defined mathematical language as a mathematical communication tool that is formed because of fusing the unique vocabulary of mathematics with the language used daily.

The researcher concluded that the participants listed the factors affecting the effective use of mathematical language as 1) Difficult, 2) Language of Daily Life, 3) Time, 4) Curriculum, 5) Attitude, 6) Incomplete, and 7) Practice. Rubenstein and Thompson (2001, 2002) listed the difficulties in learning mathematical language as the meanings of mathematical words, terms, and symbols change depending on the situation, these meanings are different from their daily use in language, different words, terms, and symbols that mean the same thing, and the same words, terms, and symbols mean different things in different situations. Yeşildere (2007) stated that some out-of-school reasons affect the acquisition of the habit of using mathematical language. He noted the first of these as the meanings of some mathematical terms are not compatible with their names or the names do not accurately convey their meanings. Other factors affecting the acquisition of the habit of using mathematical language are the different use of some mathematical expressions from those in daily life and the fact that mathematical terminology is often not used correctly in students' out-of-school lives. Additionally, another factor that affects students' acquiring the habit of using mathematical language is that some mathematical expressions are used differently in daily life.

The researcher concluded that the participants developed some suggestions to increase the effective use of mathematical language: 1) It should be included in the curriculum, 2) Activities should be prepared, 3) Visual materials should be used, 4) Undergraduate education should be emphasized, and 5) Correct, clear, understandable, and simple language should be used. Similarly, Çakmak, Çetin, and Bektemir (2016) claimed that activities for mathematical reading comprehension, writing skills, and concept knowledge can be prepared to increase the use of mathematical language, and these activities should be included in the lessons in a way that supports each other. Researchers have also suggested that these activities can be used to evaluate students in lessons. Instead of having mathematical activities with activity books and worksheets to help them understand abstract mathematical concepts, giving place to mathematical conversations and discussions in concrete experiences and games can help children overcome these difficulties (Ginsburg, 2009). Canbazoğlu and Tarım (2019) stated that to develop students' mathematical language skills, classroom teacher candidates should establish a relationship between mathematics and daily life, use concrete concepts and materials, and design activities about what should be done in the teaching environment. In this context, teachers should make sure that they use the mathematical language correctly in their lessons, warn students to be careful while teaching mathematical words, and mathematical vocabulary should be included in the lesson plans among the objectives aimed to be gained by the students (Raiker, 2002). According to Yılmaz and Türkmen (2019) experts recommended that the acquisitions that allow the mathematical language to be utilized more frequently be incorporated into the training programs.

Teaching primary school students' language development and mathematics concepts is possible with the correct use of language by primary school mathematics teachers (Çalıkoğlu-Bali, 2002). Similarly, Yılmaz and Türkmen (2019) emphasized that teachers should pay attention while using the mathematical language during the lesson and provide opportunities for students to use this language. Teachers should plan lessons in a way that will ensure active participation of students in their lessons and prepare lesson plans in which students can use mathematical language. Teachers should both use the mathematical language correctly and guide students to use the mathematical language correctly (Guzel & Yılmaz, 2020). It is crucial for mathematics teachers and students to be able to use mathematical language correctly. When using the language of mathematics, indirect expressions and metaphors are not used. In particular, direct and clear expressions are used (Çalıkoğlu-Bali, 2003). The correct use of the mathematics field language by the teacher has an advisable place in establishing a healthy communication in the classroom and in constructing mathematical concepts by the students. In that case, it should be ensured that pre-service teachers' mathematical language skills are developed in the teaching process (Akarsu, 2013). Classroom teachers are the most crucial element of the initial level. Primary school teachers' undergraduate programs should offer more courses on mathematics and teaching mathematics, and instructors should be adequate expertise (Paksu, 2013). As a result, teachers' effective use of mathematical language in mathematics teaching will positively affect students' understanding of the lesson and

make them love the mathematics lesson. In this context, it is important for teachers to have the competence to use the language of mathematics effectively, as it will increase the mathematical success of students. Therefore, both pre-service and in-service training should be given to teacher candidates and teachers to enable them to use the language of mathematics effectively.

In line with the findings obtained from the research, the following recommendations were developed:

• Classroom teachers should use mathematical language in a correct, clear, understandable, and simple way in their classrooms.

• Acquisitions related to the use of mathematical language can be added to the mathematics curriculum. Besides, a separate time can be included in the lesson plans for the use of mathematical language.

• More detailed information about the language of mathematics can be given to prospective teachers in the classroom teaching undergraduate program in the lessons related to mathematics teaching.

• The results of the research should be compared by working with pre-service teachers in different branches, teachers, and students studying at other levels.

• The number of qualitative studies can be increased to examine the use of language in mathematics teaching in depth.

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