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Who Is a Mathematics Teacher and What Does a Mathematics Teacher Do?

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Abstract

Preservice middle school mathematics teachers' (PMTs) beliefs about a mathematics teacher and mathematics teaching were investigated through the metaphors they generated. Third- and fourth-year PMTs ($N = 249$) at four universities in Türkiye participated in two anonymous metaphor tasks for a mathematics teacher and mathematics teaching. PMTs' metaphors were first analysed by the framework developed for and used in previous studies exploring teachers' metaphors (Löfström et al., 2011) with further elaborations. PMTs' metaphors for a mathematics teacher and mathematics teaching were categorised and compared. Then, deeper analyses of hybrid, self-referential, and contextual metaphors were conducted. Findings revealed that PMTs mostly used didactical expert and self-referential metaphors for the mathematics teacher and hybrid and self-referential metaphors for mathematics teaching. PMTs' beliefs about mathematics teaching seemed to be more multifaceted than their beliefs about a mathematics teacher. The deeper analyses showed that PMTs associated both the teacher and teaching with positive and/or negative connotations in their self-referential and contextual metaphors. Documenting these beliefs through metaphors allowed us to explore and understand the nature of PMTs' beliefs and showed that metaphor tasks could be useful for detecting beliefs.

Keywords Beliefs · Mathematics teaching · Mathematics teacher · Metaphor · Preservice teachers

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Introduction

Beliefs represent what individuals think about themselves and the world as well as the relationship between the two when they participate in different social contexts such as those including mathematics teachers and students (Cross, 2009). Preservice teachers' beliefs guide them as they learn to teach in teacher education programs and in their future career (Arslan et al., 2022). Preservice teachers bring beliefs from their previous classroom experiences to their teacher education program and may change some beliefs to align with the program's goals (Horgan & Gardiner-Hyland, 2019; Wall, 2016). Therefore, it is important to focus on preservice teachers' beliefs in order to determine the effectiveness of teacher education programs (Horgan & Gardiner-Hyland, 2019).

Metaphors reveal teachers' understandings, assumptions, and perceptions about teaching and learning, the classroom environment they prefer, and being a teacher (Erickson & Pinnegar, 2017). They express what preservice teachers consider as important traits for mathematics teachers (Gomez, 2021) and reveal the meanings they associate with teachers and teaching that may be difficult to detect when they talk about their work (Oksanen & Hannula, 2012). Hence, they are effective tools to explore preservice teachers' beliefs about mathematics teaching and learning (Reeder et al., 2009).

The present study investigated the beliefs of preservice middle school mathematics teachers (PMT) about a mathematics teacher and mathematics teaching through the metaphors they generated. Documenting these beliefs will allow us to (a) see how they picture a mathematics teacher as a possible future self and mathematics teaching as a future career, (b) see what they may prioritise in their future career, and (c) provide feedback for teacher education programs. The following research questions were explored:

1. What are PMTs' beliefs about a mathematics teacher and mathematics teaching as depicted in their metaphors?
2. What is the nature of PMTs' beliefs about a mathematics teacher and mathematics teaching?

Preservice Teachers' Beliefs and Metaphors

Teachers and preservice teachers' beliefs reflect past experiences; these beliefs affect how they teach, learn to teach, and deal with the complexities of teaching (Fives & Buehl, 2012). Preservice teachers already have beliefs about mathematics teachers and mathematics teaching when they start their teacher education program (Jao, 2017; Safrudiannur & Rott, 2022) that often influence how they make sense of new information and experiences, develop tasks, and practice in their classroom (Fives & Buehl, 2012). Therefore, teacher education programs aim to develop preservice teachers' mathematics-related beliefs that will support their learning to teach (Jao,

2017; Lloyd, 2005; Safrudiannur & Rott, 2022; Wilkins & Brand, 2004). Despite the limited influence of teacher education programs on preservice teachers' existing mathematics-related beliefs (Cross-Francis et al., 2015; Safrudiannur & Rott, 2022), the beliefs developed at the end of their program may influence their future practices (Arslan et al., 2022). Thus, exploring beliefs is vital to strengthen and develop beliefs that will help them become effective mathematics teachers (Haser & Star, 2009; Safrudiannur & Rott, 2022).

Preservice teachers hold both constructivist and traditional mathematics-related beliefs (Haser & Star, 2009; Kayan et al., 2013; Lloyd, 2005; Vesga-Bravo et al., 2022). PMTs believe that teachers should not only guide students in their learning but also transmit knowledge (Haser & Star, 2009; Köğçe, 2017) and prepare students for future life (Köğçe, 2017). They believe that students should find their own way to deal with mathematical tasks as well as learn to perform tasks by teacher-led strategies (Kayan et al., 2013). Preservice teachers come to develop more constructivist mathematics-related beliefs after mathematics teaching method courses (Haser & İşler, 2017; Jao, 2017; Wilkins & Brand, 2004). They have more constructivist general beliefs about teaching and learning (Horgan & Gardiner-Hyland, 2019; Wall, 2016) and realise that teachers have many responsibilities as they progress in the program; however, they may not recognise the contextual factors affecting teachers (Stenberg et al., 2014; Wall, 2016).

Metaphors are descriptions of an event, action, or phenomena with another by focusing on the similarities in characteristics that both have (Green, 1971; Lakoff & Johnson, 1980) and by linking our understanding of one to another (Green, 1971). They establish an important thinking process in our minds (Martinez et al., 2001). They illustrate the way individuals understand the world and provide a better conceptualization of concepts that are not well-defined (Knowles & Moon, 2006). For example, the meanings linked with a concept, person, or action (e.g., mathematics or mathematics teaching) are better explained when these meanings are mapped to a concrete metaphor (Schinck et al., 2010).

Metaphors also address a stance or a certain argument because one prefers to use a specific metaphor but not another (Saban, 2006). They provide clues about how individuals make sense of the world (Noyes, 2006) through their preferences and experiences (Zhao et al., 2010). Thus, metaphors uncover what people think about themselves in relation to others and the world and unpack their beliefs (Cassel & Vincent, 2011; Schinck et al., 2010).

Preservice teachers' beliefs have been explored through their metaphors, which reveal how they interpret the personal and professional world (Massengil Shaw & Mahlios, 2008). Preservice teachers' reflection papers about teaching and learning often contain philosophy statements that are in line with their teacher education program's expectations but have not been sufficiently internalised (Alsup, 2006). Instead, metaphors may reveal beliefs more effectively because they require more thorough thinking of personal assumptions about teaching and learning (Bullough, 1991; Erickson & Pinnegar, 2017). They allow for exploring preservice teachers' beliefs about teachers' roles and the personal meanings of their experiences, which may not be easily captured (Löfström & Poom-Valickis, 2013). Metaphors give access to unconscious or implicit beliefs, such as beliefs about teachers, which they

have since before their teacher education program (Löfström et al., 2010). Preservice teachers' metaphors for a concept provide information about positive and negative meanings they link with that concept, making them effective tools for exploring beliefs (Son & Lee, 2021).

Metaphors have been used to explore preservice teachers' mathematics-related beliefs (Bullough, 2015b). For example, Reeder et al. (2009) asked preservice teachers to produce verbal metaphors for mathematics and visual metaphors for teaching and learning mathematics, and then to describe teacher and student roles in relation to their metaphors. Most of the participants expressed authoritarian teacher roles in the mathematics classroom, whereas some stated more guiding and nurturing roles. Metaphors helped the researchers to access preservice teachers' beliefs and reflections about mathematics teaching and learning. Cassel and Vincent (2011) asked preservice teachers to produce a metaphor for teaching mathematics and then state their reasoning in order to explore their views. Most of the participants wrote metaphors about mathematics teaching as an end-product or an outcome (e.g., an answer or a solution). Some participants described teaching mathematics as a difficult and scary process, whereas others had a rather neutral tone such as a difficult process possibly with an end-product. Metaphors helped the researchers to enhance practices for these preservice teachers to lead them towards a more positive view of teaching mathematics. Son and Lee (2021) asked preservice teachers to define problem solving, create a metaphor for it, and explain the metaphor in writing. Metaphors not only revealed preservice teachers' conceptions consistent with their definitions but also positive and negative meanings they associated with their conceptions.

In this study, PMTs' metaphors were analysed based on the framework described in the next section. Then, their beliefs about a mathematics teacher and mathematics teaching were compared. Finally, hybrid, self-referential, and contextual metaphors were explored.

The Framework

Beliefs are important in becoming a teacher (Beijaard et al., 2004) and key to preservice teachers' identities by guiding their actions and understandings about their future teacher-self (Bullough, 2015a). Metaphors illustrate teachers' beliefs about teaching and their role; thus, they represent their professional identity (Alsup, 2006; Bullough, 1991, 2015a). A set of studies have explored preservice and inservice mathematics teachers' beliefs in their metaphors by the Löfström et al. (2010) extended identity model, which was based on the Beijaard et al. (2000) identity model. The present study employed the extended identity model with further elaboration to explore PMTs' beliefs about a mathematics teacher and mathematics teaching.

Beijaard et al. (2000) argued that teachers construct their identity based on their beliefs about themselves as content, pedagogical, and didactical experts reflecting the content, pedagogical, and pedagogical-content knowledge types (Shulman, 1986) and their priorities in their profession (Beijaard et al., 2004). Their model expressed teacher identity in terms of expertise. Subject matter expert teachers

have and transmit disciplinary knowledge. Didactical expert teachers are experts on planning, implementing, and evaluating teaching and learning processes to enhance students' learning. Pedagogical expert teachers support students' holistic development.

Löfström et al. (2010) extended this model to explore preservice teachers' beliefs through metaphors by adding self-referential and contextual categories. Self-referential metaphors are the expressions about teachers' personality, and contextual metaphors are about the teachers' work context. They addressed that metaphors with several categories in equal emphasis could be considered as hybrid. Later, Löfström et al. (2011) developed a manual for metaphor analysis for the Nordic-Baltic Mathematics Research Group (NorBa). The categorisation in their manual was adopted for the clarification and analysis of the metaphors in the present study.

Studies using this framework found that Finnish preservice teachers completed the statement *As a mathematics teacher, I am …* mostly by self-referential and didactical expert metaphors (Oksanen et al., 2014), whereas Finnish inservice mathematics teachers generally wrote didactical expert metaphors for the statement *Teacher is like …* (Oksanen & Hannula, 2012; Oksanen et al., 2014). Cypriot inservice mathematics teachers tended to write didactical expert metaphors for the statement *Teacher is like …* (Pantziara et al., 2017). These studies concluded that didactical expert metaphors revealed teachers' constructivist beliefs. Kvedere and Pipere (2013) asked Latvian inservice mathematics teachers to complete the statement *A teacher is like/as a …* which revealed mostly self-referential and didactical expert metaphors. They also indicated that teachers expressed positive and negative connotations in their metaphors but did not indicate the categories of the positive and negative metaphors.

One goal of the present study was to explore PMTs' beliefs about mathematics teaching through metaphors. Therefore, we elaborated on the model to analyse

Table 1 Categories of mathematics teacher and mathematics teaching metaphors

Mathematics teacher metaphors	Mathematics teaching metaphors
Subject expert: A teacher who has and transmits mathematics knowledge	Being a subject matter expert: Knowing and transmitting mathematics knowledge
Didactical expert: A teacher who focuses on teaching with a strong consideration of students' learning and structure of the mathematics concept	Being a didactical expert: Teaching mathematics by considering students' learning, possible misconceptions, and by using different approaches
Pedagogical expert: A teacher who prioritises students' well-being and who has nurturing concerns	Being a pedagogical expert: Teaching mathematics to provide a better life for students, to provide care for them
Self-referential: Teacher characteristics excluding the actual work of teachers	Self-referential: Features or characteristics of the teaching profession, without focusing on the actual work of teaching
Contextual: Characteristics of the context in which teachers work	Contextual: Characteristics of the context that teaching takes place
Hybrid: Metaphors referred to at least two of the above categories	Hybrid: Metaphors referred to at least two of the above categories

mathematics teaching metaphors that are presented in Table 1. Mathematics teaching categories addressed the act of teaching mathematics.

We had two assumptions to focus on mathematics teacher and mathematics teaching metaphor objects. First, PMTs would think about future selves, previous mathematics teachers, and/or ideal ones in their mathematics teacher metaphors, which would unpack the traits and roles they believed to be important for mathematics teachers. Second, PMTs' mathematics teaching metaphors would reveal the characteristics they associated and prioritised with the mathematics teaching profession based on their observations.

The present study employed the framework to answer the first research question. The beliefs revealed in subject matter, didactical, and pedagogical metaphors for both mathematics teacher and teaching explicitly addressed teachers' expertise in a certain knowledge area. Therefore, for the second research question, we (a) compared the mathematics teacher and mathematics teaching metaphors to see the possible differences in related beliefs, (b) explored the structure of the hybrid metaphors, and (c) examined the nature of the self-referential and contextual metaphors, which were either single metaphors or in hybrids.

Hybrid metaphors are often considered indicators of a more sophisticated understanding of teachers and teaching (Löfström & Poom-Valickis, 2013), which may provide information about the nature of such understanding. On the other hand, researchers have approached self-referential metaphors in different ways. Leavy et al. (2007) used this category to address metaphors that were not about the essential components of teaching but how preservice teachers pictured teaching; they interpreted these images as a representation of personal meanings. The decrease in self-referential metaphors was an indicator of focusing on other aspects of teaching. Portaankorva-Koivisto and Grevholm (2019) focused particularly on preservice secondary mathematics teachers' self-referential metaphors for a mathematics teacher because self-referential metaphors were preferred more by preservice teachers than inservice teachers (Oksanen et al., 2014). They investigated what teaching mathematics meant for PMTs. Self-referential metaphors revealed that PMTs tended to see the mathematics teacher as a dynamic person who was developing or starting new experiences by considering their own professional development.

Based on these studies, we explored single and in-hybrid self-referential metaphors in further analysis to enhance our understanding of PMTs' beliefs. Finally, we focused on contextual beliefs in single and hybrid metaphors to see how PMTs considered teachers' work context. Although context is important for the development of PMTs' identity and beliefs (Beijaard et al., 2004; Haser & Star, 2009), PMTs rarely think about the contexts they will teach (Stenberg et al., 2014; Wall, 2016). Exploring PMTs' beliefs about context will help us understand how they experience, observe, and perceive the contexts.

Methodology

Context and Participants

The study participants were third- and fourth-year PMTs in mathematics teacher education (MTE) programs at four universities in Ankara, Türkiye. These four-year programs train mathematics teachers specifically for middle grades (5 to 8, ages 11 to 14 years). MTE programs in Türkiye are centralised where all methods of mathematics teaching courses were offered in the third year and all practice teaching courses in the fourth year at the time of the study. Previous studies found that PMTs' mathematics-related beliefs changed the most by the end of the third year due to the methods courses but did not change in the fourth year (Haser & İşler, 2017; Kayan et al., 2013). Therefore, we approached third- and fourth-year students for the study in order to draw better conclusions for PMTs in MTE programs.

We accessed 249 PMTs after the ethical procedures were completed and invited them to complete two anonymous metaphor tasks. Among them, 225 completed the first task and 221 the second task with valid explanations. Of the 199 PMTs who responded to both tasks, two did not indicate their gender. PMTs' gender and year-level information and the number of PMTs who completed each task are given in Table 2.

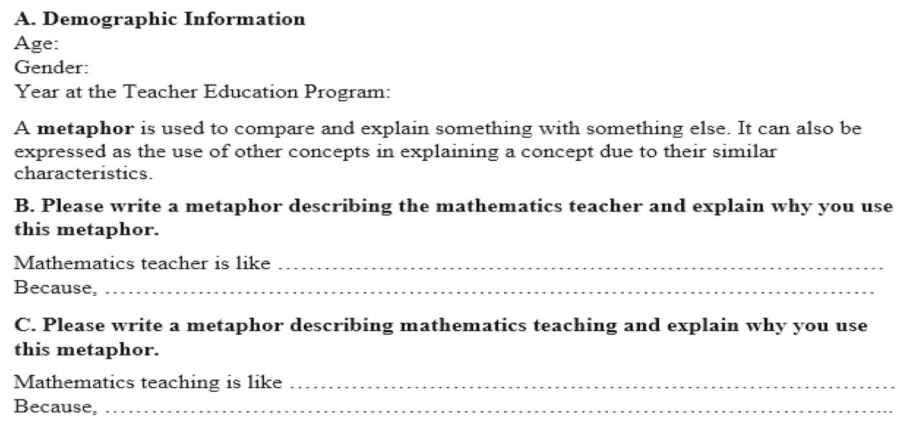
The available statistics on gender distribution at Turkish MTE programs since 2015 show that female PMTs (about 75%) outnumber male PMTs while the number of male PMTs is in an increasing trend (Higher Education Information Management System, 2023). Female PMTs at the four MTE programs where data were collected ranged between 75 and 89% since 2020 (Higher Education Information Management System, 2023). The gender distribution in our data also favoured female PMTs (86%). Therefore, although we accessed PMTs only in Ankara, the sample resembles the gender distribution of the general population.

Data Collection and Analysis Process

The data collection tool was an anonymous questionnaire (Fig. 1) of three demographic questions (i.e., age, gender, and year level in the MTE program) and two open-ended metaphor tasks. Participants were given the Turkish translation and definition of *metaphor*; then, they were asked to write a metaphor for a mathematics teacher and for mathematics teaching and to explain their reasons for choosing these metaphors. Researchers visited the third- and fourth-year courses that were obligatory for PMTs, informed the students about the study, invited them to participate,

Table 2 PMTs' gender and year-level information based on task completion

Task	Male	Female	Third year	Fourth year
1. Mathematics teacher	33	192	121	104
2. Mathematics teaching	33	186	119	102
Both tasks	29	170	106	93



A. Demographic Information
Age:
Gender:
Year at the Teacher Education Program:

A **metaphor** is used to compare and explain something with something else. It can also be expressed as the use of other concepts in explaining a concept due to their similar characteristics.

B. Please write a metaphor describing the mathematics teacher and explain why you use this metaphor.

Mathematics teacher is like .....
Because, ...

C. Please write a metaphor describing mathematics teaching and explain why you use this metaphor.

Mathematics teaching is like .....
Because, ...

Fig. 1 Data collection instrument

and distributed the questionnaire to the volunteering PMTs, which took about 20 min to complete. The study was conducted at the end of the spring semester when PMTs were about to complete their studies at their year level. Data of the study were pairs of the PMTs' metaphors and their explanations because they often used the same metaphor to describe different characteristics of a mathematics teacher and of mathematics teaching. The metaphor–metaphor explanation pairs were the units of analysis in the study and are referred hereafter as *metaphors*.

The usage of framework for metaphor analysis was discussed in several international meetings. First, metaphor data from different countries were analysed by using the analysis manual (Löfström et al., 2011) and discussed in a NorBa meeting in which the first author participated. Then, analyses of metaphors were discussed in international conferences (e.g., Haser et al., 2015; Oksanen & Hannula, 2012; Pantziara et al., 2017) with larger groups of mathematics education researchers where a common understanding and practice of metaphor analysis by using the framework was ascertained.

We responded to the first research question by categorising the PMTs' metaphors for a mathematics teacher and for mathematics teaching. We first discussed and clarified the meaning of the metaphor categorisations based on the manual and previous studies, then we separately analysed 20% of the responses selected by simple random sampling to calibrate our categorisation. We compared our findings, discussed the differences, and clarified the analysis. We analysed the data set separately, compared the findings for each PMT, discussed the disagreed cases, and decided on the final categories with 100% consensus of all authors. All metaphors were coded in an Excel file, and frequencies were calculated.

For the second research question, we focused on the hybrid, self-referential, and contextual metaphors. First, we calculated the frequency of the categories in the hybrid metaphors to see their structure. Then, we conducted an inductive analysis for all self-referential and contextual metaphors to understand the beliefs they

illustrated. Preliminary findings revealed two distinct features: the negativity/positivity of the metaphors and the reference to the nature of mathematical knowledge (for the self-referential metaphors). Next, we individually coded the self-referential and contextual metaphors based on these characteristics and compared coded data until 100% agreement was reached.

Some PMTs completed only one task, and therefore, those questionnaires were eliminated from the study. Also eliminated were those containing metaphors that described learning mathematics or mathematics and those without sufficient or any reason. It is possible that these PMTs expected a selection-type survey and did not want to spend effort on tasks that required thorough thinking and writing. As all 249 PMTs consented for the study, we analysed all data with valid explanations and removed data that we could not categorise.

Findings

PMTs' beliefs about a mathematics teacher and mathematics teaching are presented first. Then, a comparison of PMTs' metaphors for the mathematics teacher and mathematics teaching and the analysis of hybrid, self-referential, and contextual metaphors are reported.

Preservice Middle School Mathematics Teachers' Beliefs

Beliefs About a Mathematics Teacher

PMTs described mathematics teachers mostly with didactical and self-referential metaphors, then with a combination of different knowledge and characteristics in hybrid metaphors. Contextual metaphors appeared the least. Table 3 presents the frequency and percentage of categories for mathematics teacher metaphors.

Mathematics teachers were portrayed as didactical experts the most with metaphors such as "a guide," "a soccer coach," and "the captain of a ship in the ocean." PMTs believed that mathematics teachers guided the students while they were learning mathematics and helped them deal with difficulties by using different methods in their teaching.

Table 3 Distribution of metaphor categories in metaphors for a mathematics teacher

Metaphor categories	*f*	%
Didactical expert	66	29.3
Self-referential	60	26.7
Hybrid	35	15.6
Pedagogical expert	34	15.1
Subject matter expert	25	11.1
Contextual	5	2.2
Total	225	100.0

> [A cook] Because s/he knows what to do and how to do it well while teaching mathematics to students. Just like a cook who knows [how much] salt and pepper to put for each dish, a mathematics teacher knows with which method [each] student will learn a topic. S/he uses those methods. S/he uses a different model [or] material for each topic. S/he would try to make the lesson enjoyable as if a cook makes the dish more colourful and tastier by using different spices.

PMTs believed that mathematics teachers might have several roles to make students develop an interest in learning mathematics. They stated that the teacher constructed the mathematics knowledge base for students so that the students would continue building on it: "[A contractor] If a contractor uses high-quality material and properly constructs the base, the building becomes strong. Similarly, if a teacher teaches the topics by enabling meaningful learning instead of rote learning, students' mathematical knowledge becomes strong."

PMTs' self-referential metaphors for the mathematics teacher, such as "the dreams of a child," "the liver," and "a working machine," stressed both appreciation and criticism. Mathematics teachers were believed to be smart and hardworking because they dealt with a difficult content domain, and they were very patient.

> [A gardener] Because, a gardener protects her/his garden with rigour [and] grows her/his fruits and vegetables with patience. S/he spends effort for them and s/he would see the results of her/his efforts in time just like a teacher. [...] The teacher makes an effort for her/his students every day. In the end, the gardener collects fruits from her/his plants. The teacher [also] feels happy by seeing her/his students' success.

Surprisingly, several negative characteristics were also associated with mathematics teachers. They were portrayed as arrogant, not friendly, and scary: "[A robot] Because, s/he comes and teaches her/his lesson [without any enjoyment]. S/he does not try to adapt [what s/he teaches] to real life much. S/he rots her/his life and her/his students' lives within formulas."

PMTs expressed several teacher characteristics and expertise in hybrid metaphors. A mathematics teacher was like "a friend" including self-referential and didactical expert categories or "the wind" addressing subject matter and pedagogical expert categories:

> [The wind] Because mathematics teachers are the people who direct students, who prepare them for life and society. Just like the wind shapes the daily life [and] directs objects to where it wants [them to go], teachers are like this. They direct students by giving students the knowledge they need to take.

Pedagogical expert mathematics teachers supported students' development and guided them for their lives. PMTs believed that these teachers cared about and helped their students. PMTs wrote metaphors such as "the life," "the sun" and "the moon," and "a mother" and "a father": "[A father] Because he is a solid wall. One cannot do without him. He is like a pillar. He prepares [you] for life. He makes sure that you will be successful in your future life."

Subject matter expert teachers were teachers with solid mathematical knowledge and precise calculation skills expressed by metaphors such as "a smartphone" and "a computer." A mathematics teacher was like "a book" because s/he had good knowledge of mathematics and other disciplines. S/he was like "a calculator" who performed operations correctly.

> [A computer] Because a computer is a very beneficial tool that can do several complex operations in a short time period, can do several mathematical operations that people cannot make sense of, [and] pursue them to correct results as expected from [the computer].

Contextual references to mathematics teachers were mentioned the least in metaphors. PMTs pictured the mathematics teachers in contexts with rather a negative tone: "[A slave] Because a teacher has no value in this country. Furthermore, it is not a well-paid profession and, thus, I just consider her/him as a slave."

Beliefs About Mathematics Teaching

PMTs expressed mathematics teaching mostly with the hybrid and self-referential metaphors as seen in Table 4. Although PMTs wrote didactical expert metaphors the most for a mathematics teacher, they did not state being a didactical expert metaphor for mathematics teaching much. Contextual metaphors were not mentioned for mathematics teaching.

PMTs addressed mathematics teaching by hybrid metaphors the most. They believed that mathematics teaching is a complex profession that requires being an expert in different knowledge areas. One PMT described it with self-referential and didactical characteristics:

> [Planting and growing a tree] The teacher gets and educates the students when they are young. Of course, this process requires effort and care. Just like we plant a young tree and water it on time, [we teach] mathematics in line with the students' readiness, in proper timing, [with] effective explaining, attention, patience and care.

Table 4 Distribution of metaphor categories in metaphors for mathematics teaching

Metaphor categories	*f*	%
Hybrid	65	29.4
Self-referential	51	23.1
Being a pedagogical expert	43	19.5
Being a didactical expert	37	16.7
Being a subject matter expert	25	11.3
Contextual	0	0
Total	221	100.0

Although contextual metaphors did not appear as a single category, many PMTs described mathematics teaching by considering contextual factors and other aspects in hybrids.

> [Walking on a rope] Because I think teaching mathematics is a difficult job. Especially teaching mathematics [after/during] breaking down today's students' prejudices and using different methods while doing this [are difficult]. The teacher may not reach his/her purpose in case of a small mistake, just like an acrobat falls down [the rope] with a small mistake.

The second most common category was self-referential metaphors. These PMTs focused on the characteristics of mathematics teaching rather than any expertise for teaching it. There were several metaphors expressing positive and/or negative characteristics.

> [Asking a person to travel to the horizon by the boat and two paddles you give her/him] Because s/he has an unknown journey ahead of her/him. It is sometimes promising, sometimes heartbreaking. But s/he will see what s/he hoped to find at the end of the journey.

PMTs who addressed mathematics teaching as being a pedagogical expert stated that mathematics was a part of real life and teaching it was similar to teaching a life lesson. They believed that mathematics teaching was a part of human development and linked it to being a parent: "[Being a mother or father] Because sometimes the time spent with teachers is more than the time spent with parents. Therefore, teachers should treat students with parental love."

Being a didactical expert metaphors expressed the processes that mathematics teachers go through to teach. They believed that mathematics teaching should employ appropriate methods and materials to teach mathematics better.

> [Cooking a delicious meal] While cooking, first you should decide on the ingredients. We can associate it with the methods used in mathematics teaching. Afterwards, we should decide on the required amount for each ingredient. This is as if deciding on how much time we should spend on a topic in mathematics teaching. Then, we should decide on the baking time. This is like deciding on how much time should be devoted for each student. If the meal is delicious, it means that we succeed.

The least common category was teaching as being a subject-matter expert. PMTs addressed mathematics teaching as introducing mathematics knowledge to students in an accurate and correct way. In these metaphors, students were generally interpreted as passive learners.

> [Making a puzzle] Mathematics is like a puzzle whose pieces are combined to a whole. The students have an empty area. [The teacher tries to] fill out this area by the pieces [of the puzzle]. [Teacher] starts with the corners (easiest). When other pieces are added [to the corners] the image becomes more meaningful. The last piece is put and ta-da! The puzzle is completed. But, in order to gain fluency, the puzzle is broken and [the teacher] starts over.

Nature of Preservice Middle School Mathematics Teachers' Beliefs

Comparison of Mathematics Teacher and Mathematics Teaching Metaphors

PMTs seemed to picture a mathematics teacher as a person who had one major certain type of knowledge (e.g., didactical, pedagogical, or subject matter), had certain characteristics that were not related to any expertise, or had less expertise. This person was rarely expressed within a context. On the other hand, mathematics teaching was a combination of being expert in several types of knowledge and with characteristics that were not related to such expertise. Single metaphors for mathematics teaching were less than single metaphors for a mathematics teacher. PMTs did not state contextual metaphors for mathematics teaching. The differences in the distribution of teacher and teaching metaphors are illustrated in Fig. 2.

Didactical expert in mathematics teacher metaphors and being a didactical expert in mathematics teaching metaphors addressed similar beliefs about the person and what that person did to enhance student learning. Similarly, PMTs' beliefs about a mathematics teacher and mathematics teaching in relation to pedagogical knowledge emphasised the development of students whereas in relation to subject matter knowledge emphasised the strong mathematics knowledge that teachers should have and teach. These beliefs were reported in the previous sections.

We compared and explored hybrid metaphors, and single and in-hybrid self-referential and contextual categories for a mathematics teacher and mathematics teaching. We focused on self-referential metaphors to explore the traits of mathematics teachers and mathematics teaching that PMTs considered important as they convey a personal meaning (Leavy et al., 2007; Löfström & Poom-Valickis, 2013; Portaankorva-Koivisto & Grevholm, 2019) and that PMTs prioritised

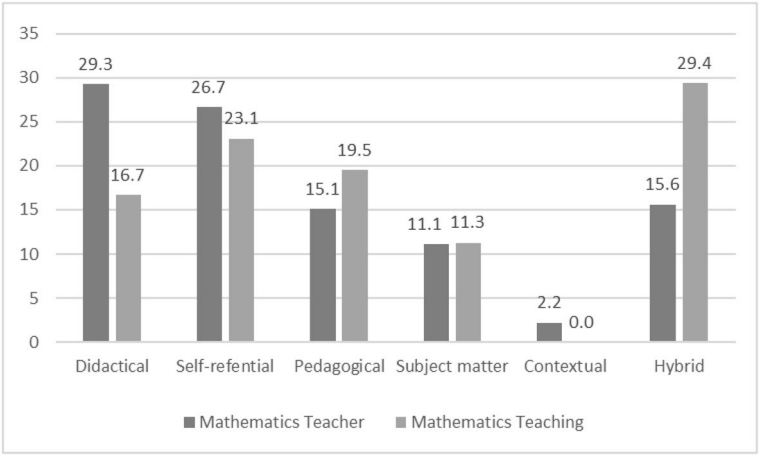


Fig. 2 Comparison of metaphor categories for mathematics teacher and mathematics teaching

self-referential metaphors to represent this meaning (Saban, 2006; Zhao et al., 2010). Contextual metaphors were explored to understand how PMTs placed the mathematics teacher and mathematics teaching in contexts in depth.

Hybrid Metaphors

Hybrid metaphors were used twice as often to describe mathematics teaching than a mathematics teacher (see Fig. 2). The structure of hybrid metaphors used for mathematics teacher and mathematics teaching is presented in Table 5 in terms of the frequency and the percentage of metaphor categories they included.

Table 5 shows that hybrid metaphors had different structures for mathematics teacher and mathematics teaching. PMTs described a mathematics teacher with didactical expertise and subject matter expertise in hybrid metaphors the most. While pedagogical and self-referential characteristics were visible, contextual references were few. On the other hand, PMTs stated self-referential characteristics and contextual factors the most in their hybrid metaphors describing mathematics teaching. Being a subject matter expert was mentioned the least.

The structure of the hybrid metaphors addressed that PMTs pictured a mathematics teacher as a person with certain types of knowledge, often disconnected from the context. They believed that a mathematics teacher (a) was primarily a didactical expert who had some expertise in subject matter and pedagogy and (b) had personality traits that were not related to any type of knowledge as expressed by self-referential expressions.

Mathematics teaching, on the other hand, primarily had self-referential features that were related to the nature of the profession. PMTs believed that being a didactical and pedagogical expert was important for mathematics teaching, but being a subject matter expert was not. This lack of emphasis on subject matter expertise could also be seen in the distribution of mathematics teaching metaphors in Table 4. A closer look at the hybrid metaphors allowed us to see that context was an important part of the mathematics teaching profession along with other characteristics, which was not visible in the general distribution presented in Table 4.

Table 5 Structure of hybrid metaphors

Hybrid metaphors	Mathematics teacher ($n=35$)		Mathematics teaching ($n=65$)	
	f	%	*f*	%
Subject matter expertise	17	21.8	5	3.7
Didactical expertise	27	34.6	29	21.5
Pedagogical expertise	13	16.7	18	13.3
Self-referential	14	17.9	44	32.6
Contextual	7	9.0	39	28.9

Self-referential Metaphors

To describe a mathematics teacher, 60 PMTs used only self-referential metaphors (see Table 3) and 14 PMTs mentioned the self-referential characteristics in hybrid metaphors (see Table 5). Similarly, 51 PMTs described mathematics teaching only via self-referential metaphors (see Table 4) whereas 44 of them described self-referential characteristics in hybrid metaphors (see Table 5).

PMTs referred to the mathematics teacher and mathematics teaching with positive characteristics, negative characteristics, both positive and negative characteristics, and with connections to the nature of mathematics. The frequencies of self-referential characteristics of mathematics teacher and mathematics teaching are given in Table 6.

Most of the self-referential metaphors (both single and in hybrids) for mathematics teacher and mathematics teaching were about positive or negative characteristics, or both. These characteristics were often related to the students.

PMTs believed that mathematics teachers were the people who attended to their students' needs and acted accordingly often with sacrifice, perseverance, and patience. In the end, there were generally positive results such as feelings of joy and satisfaction. Similarly, mathematics teaching was a job that was difficult and required patience but was enjoyable.

> [Mathematics teacher—a candle] S/he enlightens their surroundings with the mathematical knowledge s/he has, melts in time by making personal sacrifices, gets tired, spends effort, gets old; students learn, grow up. Just like the growth of a smaller candle by the drops from a bigger one.
> [Mathematics teaching—planting a tree and making it green and grow] The teacher receives the student when the student was a young tree. Of course, this process requires effort and care. Just like we plant the tree in the proper season and water on time, mathematics teaching requires good timing, effective explanation, attention, patience, and care in accordance with the students' readiness.

PMTs described a mathematics teacher and mathematics teaching with negative characteristics as well. Mathematics teachers were not liked by their students because of their poor teaching and/or personalities. PMTs believed that mathematics teaching was a difficult and tiring practice with a negative tone as below.

Table 6 Nature of self-referential metaphors

Subcategories	Mathematics teaching				Mathematics teacher			
	Single		In hybrid		Single		In hybrid	
	f	%	*f*	%	*f*	%	*f*	%
Positive characteristics	12	23.5	9	20.4	39	65	13	92.9
Negative characteristics	7	13.7	12	27.3	6	10	0	0
Positive and negative characteristics	12	23.5	7	15.9	6	10	1	7.1
Connections to the nature of mathematics	20	39.3	16	36.4	9	15	0	0

[Mathematics teacher—a gravestone] Mathematics teachers are generally very tough people who do not smile. They do not [appreciate] entertainment. They are boring people who live alone, [never smile] and [they are] without friends.
[Mathematics teaching—a hurdle race] Students interpret mathematics as a nightmare. […] Since they interpret mathematics in this way, they will cause difficulties for the teacher. They will not listen to and understand the lesson. When the teacher solves a problem, they will make up another difficulty. Until arriving at the finish line, the teacher will overcome the obstacles by continuously running and getting tired.

Some PMTs expressed positive and negative characteristics simultaneously in both single and hybrid metaphors to describe a mathematics teacher and mathematics teaching. They believed that there were positive and negative characteristics/issues that would be associated with the mathematics teacher. PMTs interpreted mathematics teaching as a difficult practice often with a negative tone but there would be some positive side at the end.

[Mathematics teacher—sometimes a robot, sometimes the peak] Mathematics teachers are sometimes like a robot [who] only memorise the formulas or cannot memorise but copy them on the board from a book or notebook, and solve one question after another as if memorised. Sometimes, they transfer the knowledge to real life very well, far from memorization; they are like the peak which seems to be difficult to reach before reaching there.
[Mathematics teaching—convincing] Mathematics is a lesson that is not liked. We have to make students like mathematics and make this lesson enjoyable for them before we teach. By this way, we can have students who are eager to participate in and learn a lesson that nobody likes and everybody thinks is difficult.

PMTs stated some characteristics of a mathematics teacher and mathematics teaching in connection to the nature of mathematics or how it was generally perceived. A mathematics teacher was the person who had the patience to help students understand the rigour in mathematics or deal with mathematics, which students perceive as difficult. The connection to the nature of mathematics was expressed for mathematics teaching the most. PMTs described mathematics teaching as a difficult practice requiring expertise, patience, and rigour and believed that not everyone was able to succeed in it. To be successful, mathematics teaching should be planned in detail, patiently, and with extra effort.

[Mathematics teachers—the sun] Several important mathematics-related experiences, findings, topics, happenings and concepts can be seen in life. […When the student] enters into the nature of mathematics, his/her ability to find solutions for the problems he faces in real life increases. […Mathematics teacher] will show him/her that real life problems can be solved just like mathematics problems. In other words, [the teacher] will turn [the students'] night to day like the sun.

> [Mathematics teaching—growing a flower] It requires patience and effort just like [growing] flowers. It is difficult to think mathematically without understanding the basics of mathematics. You cannot grow a flower without seeding.

Contextual Metaphors

Contextual metaphors were stated the least often in mathematics teacher metaphors. There was no single contextual metaphor for mathematics teaching. However, hybrid metaphors of mathematics teaching had several references to contextual factors. It seemed that when the focus shifted from the teacher to the teaching, contextual factors became more important for PMTs (see Table 5).

Contextual metaphors for a mathematics teacher (both single and in hybrids) expressed that the perception of mathematics as a difficult lesson puts teachers in a difficult and disadvantaged position. Mathematics teachers were not considered as important or valuable.

> [Mathematics teachers—an alien] I think that students see the mathematics teachers as aliens. As if we are from a different planet, students do not understand us [or] what we say, they cannot communicate with us, and they are scared of us.

Similarly, without exception, all PMTs who stated contextual aspects in hybrid metaphors of mathematics teaching described the context with negative characteristics. They believed that students feared and felt anxious about mathematics lessons and that existing judgments in society led students to develop such views and feelings for mathematics lessons.

> [Mathematics teaching—making a camel jump on the other side of a ditch {a Turkish idiom}] Both students and parents have prejudices about mathematics. It is the most difficult lesson for them and they believe that it is useless in real life."

Discussion and Conclusion

Analysing metaphors, comparing mathematics teacher and mathematics teaching metaphors, and focusing on the hybrid, self-referential, and contextual ones provided new perspectives on the nature of PMTs' beliefs. As metaphors illustrate preservice and inservice teachers' preferences and personal assumptions (Erickson & Pinnegar, 2007; Saban, 2006; Zhao et al., 2010), what they believe to be important for teachers (Gomez, 2021), and meanings they associate with teachers and their work (Löfström & Poom-Valickis, 2013), we now interpret and discuss that our findings address what PMTs prioritise for a mathematics teacher and mathematics teaching.

The findings showed that these PMTs generally pictured a mathematics teacher as a person with one dominant type of knowledge or characteristic, mostly as a didactical expert. PMTs stressed the patience, smartness, and perseverance of mathematics

teachers. The emphasis on single-category metaphors and the relatively small number of hybrid metaphors indicate that PMTs had not yet developed a more complex understanding of a mathematics teacher and their roles and expertise (Löfström & Poom-Valickis, 2013). This could be explained in several ways. First, PMTs might believe that a certain type of knowledge was most important to becoming a teacher (Gomez, 2021) or that they needed to possess or strengthen certain knowledge and skills. Alternatively, we speculate cautiously that PMTs could be still forming their beliefs about a mathematics teacher as they are in the process of learning different aspects of becoming one and reflect this learning on their metaphors. For example, methods courses possibly led them to prioritise didactical expertise, addressing the possible effect of these courses on PMTs' beliefs (Haser & İşler, 2017; Jao, 2017; Kayan et al., 2013; Wilkins & Brand, 2004).

PMTs seemed to think about a mathematics teacher as an individual out of any context. It is possible that they focused on enhancing their knowledge for teaching in the MTE program and rarely thought about the multiple contexts that they would put their knowledge into practice as the teacher. It is also possible that they had limited knowledge about the wider contextual factors affecting teachers directly (Stenberg et al., 2014; Wall, 2016) and, therefore, had not yet developed related beliefs. The rare contextual metaphors, however, were addressing a negative image of mathematics teachers in broader social contexts.

It could be expected that PMTs would consider mathematics teaching mainly as being a didactical expert because they considered a mathematics teacher mainly as a didactical expert. However, PMTs stated hybrid metaphors the most, which indicated a multifaceted conceptualization of mathematics teaching (Löfström & Poom-Valickis, 2013). They often addressed it as a difficult job requiring didactical expertise and some more within a negative context. PMTs seemed to be aware of the contexts in which mathematics teaching takes place and had previous observations and experiences about the effect of classroom and broader contexts, which could be a base for their beliefs (Safrudiannur & Rott, 2022).

PMTs did not often state subject matter knowledge-related metaphors for a mathematics teacher and mathematics teaching, indicating they might not believe that mathematics teachers simply transmit knowledge. Combined with the dominance of didactical metaphors, it is possible to conclude that PMTs had constructivist beliefs as previous studies using the framework had concluded (Oksanen & Hannula, 2012; Oksanen et al., 2014). However, we argue that these findings should be supported by other means of data in order to conclude that PMTs had constructivist beliefs. Instead, it is possible to claim that PMTs mostly stated beliefs in line with constructivist views. On the other hand, being a subject matter expert category was almost non-existent in mathematics teaching metaphors. This is worrying because PMTs tend to believe that mathematics content courses in MTE programs are not useful for teaching middle-school mathematics (Dilberoğlu, 2015) and they already know what they will teach in the future (Çelikdemir, 2018). Therefore, they may not prioritise mathematics knowledge for a mathematics teacher and mathematics teaching despite its importance.

Pedagogical expertise was also expressed less often. PMTs believed that mathematics teachers prepare students for life, as found in previous studies (Köğçe, 2017),

and mathematics teaching is about helping students develop as a person. PMTs in MTE programs do not spend time with students as their teacher in middle-school classrooms even during practice teaching (Haser & Star, 2009). Therefore, it is possible that they stated related metaphors less because they did not have sufficient experiences with students, which would affect their beliefs.

The findings about the mathematics teacher metaphors seemed to be similar to those found in studies in Finland with the same framework (e.g., Oksanen et al., 2014). Despite the differences in Finnish and Turkish mathematics teacher education programs and the metaphor statements asked in the Finnish study and the present study, PMTs in both programs prioritised didactical and self-referential characteristics for the mathematics teacher. This may contribute to previous findings about the effect of teacher education programs on preservice teachers' beliefs (Cross-Francis et al., 2015; Haser & İşler, 2017; Kayan et al., 2013; Wilkins & Brand, 2004) and address further research where preservice and inservice teachers' metaphors are compared across countries to explore systemic factors affecting beliefs (Kvedere & Pipere, 2013).

PMTs seemed to have a more multifaceted understanding of the mathematics teaching than of the mathematics teacher. There may be several reasons for this. PMTs observed many teachers until they started to study in the MTE programs. Thus, they may think about these observations to reach a more comprehensive understanding of teaching—not only mathematics teaching. Although they have observed many teachers, a mathematics teacher might have a more personal meaning for them, which they were still building. Thus, they might prioritise a certain type of mathematics teacher knowledge, probably the one they reflected on the most.

Exploring self-referential and contextual metaphors helped us understand more about this meaning-making process. These metaphors revealed the positive and negative meanings PMTs associated with mathematics teachers and mathematics teaching. Mathematics teaching was a difficult job because of societal prejudices, which PMTs believed to be a negative issue. Cassel and Vincent (2011) found similar negative views of mathematics teaching in preservice elementary teachers' metaphors. PMTs in the present study also had negative thoughts about mathematics teachers, which was found for inservice mathematics teachers earlier (Kvedere & Pipere, 2013). PMTs who expressed negative views of mathematics teachers might have expressed their beliefs about how mathematics teachers were seen by students, which possibly reflected their earlier experiences with mathematics teachers (Lutovac & Kaasila, 2014). To understand how such beliefs may affect PMTs' learning in the programs and in their initial years in teaching, teacher education programs should carefully explore the negative connotations in PMTs' beliefs with their reasons.

Metaphors provide us with a tool to reveal PMTs' beliefs, which might not be visible otherwise (Löfström & Poom-Valickis, 2013), especially when they address negative issues. The framework does not explicitly state the positive/negative connotations that can be associated with the object of the metaphor. Analysis of self-referential and contextual metaphors helped address these connotations and provided more information about their nature and possible ways to analyse them in the future studies.

Although metaphors are effective tools to explore PMTs' beliefs, they may limit the person who constructs the metaphor to focus on only one concept but not the others

(Lakoff & Johnson, 1980). Therefore, metaphors would not be effective in exploring belief systems, rather they may reveal core beliefs (Bullough, 2015a). PMTs might have written a metaphor about the aspect they prioritised over others. Yet, the existence of hybrid metaphors shows that metaphors can reveal a more comprehensive set of beliefs. The findings were also limited to the third- and fourth-year PMTs in the specific MTE program at four universities in Ankara, Türkiye. Preservice secondary mathematics teachers may prioritise different aspects of mathematics teachers and mathematics teaching, such as those related to subject matter knowledge. It is also possible that, if metaphor tasks were asked in different ways, PMTs might have responded differently. Yet, this specific way of asking and thorough analysis revealed information about PMTs' beliefs that could provide new directions for teacher education programs. It should be noted that (a) the findings represent the beliefs of a female-dominant sample that was conveniently selected from a female-dominant population of PMTs and, therefore, a female bias is possible and (b) the data analysis was not externally validated at the time of the analysis but was discussed in international meetings.

Teacher education programs should focus on providing experiences that support PMTs to develop/strengthen multifaceted beliefs by emphasising the importance of different types of knowledge and the multiple contexts they will teach. Blending different course experiences (e.g., mathematics content, methods, educational science, and practice teaching courses) and designing relevant experiences could make PMTs more aware of the relationship among their learning in different courses, being a mathematics teacher, and teaching mathematics. Collecting their metaphors at the end of each year in the program, along with other data, could help explore how their beliefs develop through the program and provide input for further experiences. Although the framework used in the study was comprehensive, researchers may consider possible extensions to include other types of knowledge or characteristics that may be revealed in different teacher education programs.

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