What can metaphor tasks offer for exploring preservice mathematics teachers' beliefs?

Çiğdem Haser

What can metaphor tasks offer for exploring preservice mathematics teachers' beliefs?

Çiğdem Haser

University of Turku, Faculty of Education, Finland; cigdem.haser@utu.fi

The purpose of this study was to investigate preservice middle school mathematics teachers' (PMT) beliefs about the nature of mathematics in metaphor tasks when they are designed and analyzed in different ways and their beliefs about mathematics teacher. Nine PMTs attending the practice teaching course completed four metaphor tasks (two open-ended, two structured) about mathematics, mathematics teacher, mathematics teaching and learning through the semester. The metaphors they produced were analyzed both by the revised version (Löfström et al., 2010) of the identity framework by Beijard et al. (2000) and with an inductive analysis. Findings suggested that employing open-ended task structure and inductive analysis might provide more information about PMTs' beliefs about the nature of mathematics even in metaphors that are not constructed for mathematics.

Keywords: Metaphors, beliefs about mathematics, preservice middle school mathematics teachers.

Metaphors and beliefs

Metaphors are the constructs that are used to explore one concept/happening/issue by the help of another (Lakoff & Johnson, 1980) and are used to interpret the complexity of teaching and learning interaction components (Saban, 2006). Metaphors are among the tools that enable teacher educators have access to and explore the preservice teachers' beliefs (Reeder, Utley & Cassel, 2009). Resarchers have often asked preservice teachers about their metaphors especially about teaching and learning to make sense of their beliefs and their implicit theories about education (Leavy, McSorley, & Bote, 2007). Metaphors are also used in teacher education programs to make preservice teachers reflect on their beliefs (Noyes, 2006) and to increase their awareness of their beliefs and teacher selves, to build connections between these selves and teaching, and further to change their beliefs (Saban, 2006).

Several studies have explored preservice (Haser, Arslan, & Çelikdemir, 2015) and inservice (Oksanen & Hannula, 2013; Pantziara, Karamanou, & Petridou, 2017) mathematics teachers' beliefs about mathematics teacher through metaphors by using the framework developed by Löfström et al. (2010) based on the identity framework of Beijard, Verloop and Vermunt. (2000). Beijard et al. (2000) suggested three teacher identity categories as *subject matter expert*, *pedagogical expert* and *didactical expert*. They explained that teacher as a subject matter expert knows mathematics well and transmits this knowledge to the students. Teacher with a pedagogical expertise cares about students' well-being and their growth as a person. When teachers are didactical experts, they organize teaching and learning environments to guide students in their learning efforts. Löfström et al. (2010) further suggested that teachers have characteristics that do not fit the three identity categories defined earlier as in *self-referential* metaphors, and the

contextual references to the teacher identity could also be seen in metaphors. The mentioned studies showed that the identity framework could be used to explore preservice and inservice teachers' beliefs about mathematics teacher and what they prioritize for the work mathematics teachers do. These studies have found that Cypriot teachers of grades 10-12 (Pantziara et al., 2017) and Finnish teachers of grades 7-9 (Oksanen & Hannula, 2013) prioritized didactical expertise for mathematics teachers. Mathematics teachers in these studies addressed self-referential metaphors after didactical expert metaphors. Although these metaphors are likely to address teachers' other mathematics-related beliefs (Haser et al., 2015), such an analysis has not been reported in these studies.

Similarly, when we asked Turkish preservice middle school mathematics teachers (PMTs) to write a metaphor for the mathematics teacher and explain it, they prioritized didactical expertise (Haser et al., 2015). In our unpublished analysis, we found that PMTs referred to the nature of mathematical knowledge, how it is related to other fields of science and that mathematics teachers needed to know about these characteristics of mathematical knowledge, while explaining their metaphors for mathematics teacher. Such reference to the nature of mathematics suggested adopting an inductive approach to the analysis of metaphors' explanations in order to trace PMTs' beliefs about the nature of mathematics, even when these metaphors were not constructed for mathematics.

Considering the findings of previous studies, which explored preservice and inservice teachers' mathematics related beliefs through metaphors, the purpose of this study was to investigate what metaphors can offer for understanding PMTs' mathematics related beliefs, and specifically beliefs about the nature of mathematics, even when they were not constructed for mathematics. The study also explored the change in PMT's beliefs about mathematics teacher. PMTs' explanations for metaphors, which were used in a practice teaching course as a reflection tool, were analyzed by the above-mentioned revised identity framework and by inductive analysis to explore PMTs' beliefs.

Method

The study was conducted in a middle grades (5 to 8) mathematics teacher education program in Turkey. All nine (female) PMTs attending the practice teaching course section that I taught were the participants of the study. PMTs have completed mathematics teaching methods courses and school experience course, and they were in the last semester of the program except for one student who had two more courses to take. They attended the same practice school for six hours each week, observed several mathematics teachers during the semester, completed emerging tasks in the school, and taught mathematics for at least one class hour. They also attended two hours of University course that I taught every week and discussed the emerging themes and issues of the week from the mathematics lessons they observed, and completed in-class tasks such as constructing metaphors and their explanations for mathematics related themes. The data of the study were PMTs' responses to the four metaphor tasks they completed during the class hours (50+50 minutes) and the detailed course notes that I kept during the course. Table 1 presents the content of the metaphor tasks used in the study through the semester (15 weeks).

Task 1 and Task 2 were considered as *open-ended tasks* because PMTs were only asked to construct a metaphor and explain it, and they were not asked to consider this in a certain way. Task 3 and Task 4, however, were considered as *structured tasks* because PMTs were asked to select one

theme, construct a metaphor for it, then think about relationships of this theme to the others, and construct metaphors for these themes.

Tasks and weeks	Content of the metaphor tasks
Task 1 (1st week)	Math teacher is like …… Because……. Math teaching is like …...Because ……..
Task 2 (2nd week)	Math is like …… Because ……..
Task 3 and Task 4 (3rd week and 15th week)	Choose a starting theme (math, math teacher/teaching/learning) and construct a metaphor for this theme. Then, connect it to the remaining themes by constructing related metaphors for them. Please explain the relationships.

Table 1: Metaphor tasks

Initial data analysis focused on the explanations for mathematics teacher metaphors to reveal PMTs' beliefs about mathematics teaching by employing the revised framework. Then, I conducted an inductive analysis (Miles, Huberman, & Saldana, 2014) for all metaphor explanations in order to explore PMTs' beliefs about mathematics. First, I read all the explanations for metaphors in detail and took notes on possible codes such as, mathematics in daily life and connectedness of mathematical knowledge. Next, I went through data once more and coded the data with the code list I developed with room for possible new codes such as, mathematics-related skills. The analysis was completed after no new codes were generated and all data were analyzed with all the codes. The metaphors themselves were not the focus of the analysis because there were several cases that PMTs explained the same metaphor in different ways throughout the tasks. Or, they used different metaphors in each of the tasks for mathematics teacher and still referred to the same teacher expertise in their explanations for these metaphors. Therefore, the focus of the analysis was on PMTs' explanations for their metaphors.

Findings

First, findings related to the mathematics teacher expertise that PMTs prioritized are presented. Then, findings about beliefs about the nature of mathematics extracted from PMTs' explanations for all the metaphors were presented for each metaphor task. Metaphors PMTs used are reported briefly.

Beliefs about mathematics teacher through the semester

PMTs wrote a metaphor for mathematics teacher and the explanations for their metaphors in Task 1, Task 3 and Task 4. The analysis of the explanations for their mathematics teacher metaphors through the revised framework is given in Table 2. The types of expertise identified in the metaphor explanations are indicated by "D" for didactical expert, "SM" for subject matter expert, "P" for pedagogical expert, and "SR" for self-referential as indicated in the revised framework.

PMTs prioritized didactical expertise (cook, driver, pine tree) for mathematics teachers. Almost all participants in all tasks explained how a mathematics teacher is a didactical expert. PMT6 and

PMT9 addressed only didactical expert in their explanations in all three tasks and PMT1, PMT5 and PMT8 prioritized other expertise (mostly subject matter) in their explanations in addition to the didactical expertise. PMT2, PMT3 and PMT4 addressed didactical expertise in two of the three tasks and PMT1, PMT5 and PMT7 addressed subject matter expertise (calculator manual, tour guide) in their explanations for two of the three tasks.

Participants	**Task 1**	**Task 3**	**Task 4**
PMT1	D, SM	D	D, SM
PMT2	D, P	D	SR
PMT3	D, SR	SR	D
PMT4	P	D, SM	D
PMT5	D, SM	D, P	D, SM
PMT6	D	D	D
PMT7	SM, SR	SR	D, SM
PMT8	D, SM	D	D
PMT9	D	D	D

Table 2: Participants' identities as determined in the metaphors about mathematics teacher

These findings showed that in the beginning of the semester PMTs tended to believe that mathematics teachers were mostly didactical experts. This focus on teachers' didactical expertise increased as the semester progressed. They also addressed subject matter expert, self-referential and pedagogical expert identities. Hybrid metaphors mostly included didactical and subject matter expertise, and did not include more than two expertise. Context did not appear in PMTs' metaphors.

Mathematics in mathematics teacher and mathematics teaching metaphors (Task 1)

Five PMTs mentioned about the nature of mathematics in their explanations of the mathematics teacher metaphor. Mathematics is discovered by the help of the teacher (PMT1, PMT6) who also guides for other skills such as "*problem solving, critical thinking*" (PMT9) and building connections between mathematics, daily life and other sciences (PMT5).

Seven PMTs mentioned about the nature of mathematics while explaining the mathematics teaching metaphor (using magnifying glasses, making the light available for everyone). There were references to mathematics in real life (PMT3, PMT5, PMT6) and mathematics related skills such as "*interpreting the world differently*" (PMT3). Teaching mathematics was also framed in terms of characteristics PMTs associated with the nature of mathematics such that it can be discovered (PMT1, PMT3), it includes connections (PMT8), and it is expanding (PMT3, PMT9).

Most of these PMTs stated in their explanations that since mathematics has certain characteristics, mathematics teacher or mathematics teaching must be in a certain way. Some even constructed a metaphor for mathematics for the explanation first, and then framed mathematics teacher or

teaching based on this metaphor. Even tough mathematics was a beginning point for most PMTs, the teacher and teaching metaphors they constructed seemed disconnected in Task 1, such as P9's metaphor for mathematics teacher (bitter syrup for students) and teaching (filming an advertisement).

Mathematics in mathematics metaphors (Task 2)

PMTs' explanations for their metaphors about mathematics (the code for existence, atmosphere, infinite chain of paper-clips) emphasized the necessity of mathematics in daily life (PMT6, PMT7, PMT9). Besides, mathematics is fundamental to understanding the life, the nature, and the other sciences (PMT2, PMT3, PMT6). Therefore, mathematics is important and needed (PMT2, PMT6, PMT9). PMT5 mentioned about the infinite nature of the mathematical knowledge. Only PMT9 emphasized that we use skills such as "*understanding situations, problem solving, foreseeing causes [and related] consequences, or evaluating*" while doing mathematics. PMT8 used "*being an explorer*" as a metaphor for mathematics and emphasized that mathematical knowledge is discovered or newer ways of reaching mathematical knowledge are discovered.

Mathematics in mathematics related metaphors – 1 (Task 3)

Task 3 and Task 4 asked PMTs to select one theme, construct a metaphor for that theme, and then continue to construct metaphors for the other themes. Eight of the PMTs started with a metaphor for mathematics in Task 3. Then, seven of them continued with either mathematics teacher or mathematics teaching themes. PMT4 started with mathematics teacher, continued with mathematics and then, with mathematics teaching.

The explanations for mathematics metaphors (flower, second mother tongue, fruit tree) emphasized that mathematics is fundamental to life and other sciences and humanity needs mathematics (PMT6, PMT9). Mathematics concepts are related to each other:

> Mathematics is like chess. Because mathematics has rules, theorems and formulas […] related to each other and all of those compose mathematics. Chess also has certain rules, strategies; and since there are relationships between strategies and more explicitly, since [strategies] change based on each move, mathematics is like chess. (PMT1)

There is always something to discover in mathematics (PMT9), it promotes analytical thinking (PMT2), and we always come across mathematics in our daily lives (PMT2, PMT6, PMT7, PMT9).

Metaphors about mathematics teaching and mathematics teacher did not reveal beliefs about mathematics in Task 3. Only PMT1 referred to the new ways to reach mathematical knowledge in her metaphor for mathematics teacher and PMT8 emphasized that mathematics helps us develop real life relationships in her explanation for her metaphor for mathematics teaching.

Mathematics in mathematics related metaphors – 2 (Task 4)

Similar to Task 3, all participants except PMT4 started Task 4 by constructing a metaphor for mathematics, and they continued with a metaphor for the mathematics teacher or mathematics teaching. This time, PMT4 started with a metaphor for the mathematics teaching, and then continued with mathematics and mathematics teacher.

Metaphors for mathematics (second mother tongue, water, endless travel) addressed that mathematics is an expanding field and it is infinite (PMT2, PMT3, PMT7). It is fundamental to life like "*the atmosphere. Atmosphere covers the earth and it is important for life*" (PMT6) and human beings need it. Similarly, they need mathematics. It improves and changes our ways of thinking (PMT9) and it is in our everyday life (PMT5, PMT6, PMT9).

Only PMT9 wrote about discovering mathematical concepts in her metaphor for mathematics teacher and PMT5 stated that mathematics is in our daily life. PMT9, in her metaphor for mathematics teaching, referred to the skills that (knowing) mathematics provides, the coherence among the mathematical concepts and that human beings need mathematics.

PMTs realized that they could not connect their metaphors about mathematics, mathematics teacher and mathematics teaching all the time and claimed that this was challenging in both Task 3 and Task 4. They did not prefer to state metaphors for mathematics learning in Task 3 and Task 4. The metaphor explanations did not refer to students most of the time.

Conclusions and discussion

The analysis of explanations for the mathematics teacher metaphors showed that most of the PMTs seemed to prioritize teachers' didactical expertise, most probably due to spending considerable time in the practice school and program's emphasis on improving didactical skills (Haser et al., 2017) especially in the last semester. This didactical expertise emphasis and explanations for mathematics teaching metaphors included several references to the nature of mathematical knowledge.

PMTs expressed very similar beliefs about mathematics across the tasks and these beliefs did not change much as the semester progressed. Mathematics was at the center of real life and other sciences. Therefore, humanity needed mathematics. Knowing or being able to do mathematics provided several skills such as problem solving and analyzing complex situations better. Mathematical knowledge was expanding and it could be discovered. These beliefs were not only in their metaphors for mathematics, but also in their metaphors for mathematics teacher and teaching in Task 1, and they did not change from the beginning to the end of the semester, suggesting that these beliefs might be held by the PMTs more strongly.

Inductive analysis of open-ended metaphor tasks about mathematics teachers and teaching provided more clues about PMTs' beliefs about the nature of mathematical knowledge when the metaphors were not constructed for mathematics in Task 1. However, the metaphors for mathematics teacher and teaching in Task 1 were very disconnected even though these metaphors were asked in the same task. This disconnectedness might have led them towards describing the nature of mathematical knowledge in all the metaphor explanations to provide a base for framing their metaphors for teachers and teaching. This, in turn, provided more clues about PMTs' beliefs about the nature of mathematics and suggested that these beliefs could be the base for their beliefs about mathematics teaching and teacher. It might also be the case that PMTs' beliefs about the nature of mathematics are persistent but their beliefs about mathematics teachers, teaching and learning are still under construction. Therefore, they might prefer to build their metaphors for teacher and teaching around mathematics metaphors and explanations.

PMTs preferred to start the structured tasks in Task 3 and Task 4 by first constructing a metaphor for mathematics, and then the others. These findings might address that even when PMTs prioritize didactical expertise for mathematics teachers, their beliefs about the nature of mathematics might be at the center of their beliefs about a mathematics teacher and teaching. They might be building an understanding of the work of mathematics teacher and the duties of mathematics teaching around how they believed about the nature of mathematical knowledge.

PMTs' explanations for mathematics teacher and mathematics teaching metaphors in structured tasks in Task 3 and Task 4, on the other hand, rarely referred to the nature of mathematical knowledge. Starting the structured tasks by first constructing a metaphor for mathematics, and then connecting this metaphor with the metaphors for other themes without referring to the nature of mathematics might indicate that they already have constructed the metaphor for mathematics and this provided them with the necessary base for their metaphors for mathematics teacher and teaching.

There were very few mathematics learning metaphors even though PMTs were encouraged to construct in Task 3 and Task 4. The explanations for other metaphors rarely referred to the students, most probably due to focusing more on the teachers in the practice school.

In both types of metaphor tasks, the theme-metaphor-explanation flow did not seem coherent in many cases. Mathematics, for example, was addressed with verb metaphors, such as "*playing chess*", and mathematics teaching was addressed by noun metaphors, such as "*gossip*." PMTs seemed to describe one theme while actually explaining another. Such incoherence might show that PMTs were confused about the properties of the metaphors while they were trying to construct them. Indeed, field notes indicated that PMTs struggled and spent considerable effort and time to construct metaphors and explanations, although all tasks included information about metaphors and their functions. We discussed through the semester about how metaphors would help them to think deeply and increase their awareness about the issues of teaching mathematics. Yet, they had difficulties in finding metaphors in at least one task. They wrote detailed explanations that did not always fit the metaphor.

Why not asking directly about PMTs' beliefs but asking metaphors instead? Constructing a metaphor for a concept requires thinking about the characteristics of the concept in order to find a metaphor object, which shares similar characteristics with the construct (Saban, 2006). This process might direct PMTs to think about details, connections, and relationships more deeply than responding to a direct question. In this study, the inconsistencies between metaphors and explanations might indicate that PMTs are still struggling with building these concepts or have realized the complexity of these concepts and have difficulties in finding a metaphor for such complexity. Therefore, metaphors might be a powerful tool to reveal PMTs' such incomplete processes for teacher educators and to increase PMTs' awareness of their thinking process.

Although the actual metaphors were not the major focus of the present report, it appeared that PMTs' metaphors resembled similarities to the ones reported in the literature such as mathematics as a language, journey, structure and toolkit (Noyes, 2006) and mathematics teaching as a journey and growth (Reeder et al., 2009). A further analysis is needed to explore these metaphors.

Findings of the study showed that different uses and analyses of metaphor tasks might provide different ways of exploring PMTs' mathematics related beliefs. However, the findings are limited to the nine PMTs who participated in this study, the metaphors and explanations they constructed, the ways metaphors were asked and written data. They expressed difficulty in constructing a metaphor and the need to know the properties of the metaphor object to construct it better. Therefore, the key issues in employing metaphors as tools of reflection in teacher education might be helping PMTs focus on connectedness and coherences of their ideas, reflect more on their beliefs, and their willingness to adopt and use metaphors in this process.

References

Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers' perceptions of professional identity: An exploratory study from a personal knowledge perspective. *Teaching and Teacher Education*, *16*, 749–764.

Haser, Ç., Arslan, O., & Çelikdemir, K. (2015). Mathematics teachers in preservice teachers' metaphors. In K. Krainer & N. Vondrova (Eds.), *Proceedings of the ninth congress of European research in mathematics education (CERME9)* (pp. 1188–1194). Prague, Czech Republic: Charles University.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.

Leavy, A. M., McSorley, F. A., & Bote, L. A. (2007). An examination of what metaphor construction reveals about the evolution of preservice teachers' beliefs about teaching and learning. *Teaching and Teacher Education, 23*, 1217–1233.

Löfström, E., Anspal, T., Hannula, M. S., & Poom-Valickis, K. (2010). Metaphors about 'the teacher': Gendered, discipline-specific and persistent? In J. Mikk, M. Veisson, & P. Luik (Eds.), *Teacher's personality and professionalism. Estonian studies in education* (pp. 105–122). Frankfurt am Main, Germany: Peter Lang Publishers House.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: a methods sourcebook (3rd ed.)*. Thousand Oaks, CA, United States: Sage Publications, Inc.

Noyes, A. (2006). Using metaphor in mathematics teacher preparation. *Teaching and Teacher Education*, *22*, 898–909.

Oksanen, S. & Hannula, M. S. (2013). Finnish mathematics teachers' beliefs about their profession expressed through metaphors. In M.S. Hannula, P. Portaankorva-Koivisto, A. Laine, & L. Naveri (Eds.), *Current State of Research on Mathematical Beliefs XVIII: Proceedings of the MAVI 18 Conference* (pp. 315–326). Helsinki: Finnish Research Association for Subject Didactics.

Reeder, S., Utley, U., & Cassel, D. (2009). Using metaphors as a tool for examining preservice elementary teachers' belief about mathematics teaching and learning. *School Science and Mathematics, 109*(5), 290–297.

Pantziara, M., Karamanou, M., & Petridou, A. (2017). Upper secondary mathematics teachers' beliefs expressed through metaphors. In T. Dooley, & G. Gueudet (Eds.). *Proceedings of the*

Tenth Congress of the European Society for Research in Mathematics Education (CERME10) (pp.1170–1177). Dublin, Ireland: DCU Institute of Education and ERME.

Saban, A. (2006). Functions of metaphor in teaching and teacher education: A review essay. *Teaching Education, 17*(4), 299–315.