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Prospective Teachers' Views of "Mathematics Learning"

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Abstract: *The European framework for "Key Competences for Lifelong Learning" the term "mathematical competence" means the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday life. In this context, the way prospective teachers perceive mathematics learning becomes significant. The aim of this study is to identify prospective mathematics teachers' metaphorical images with respect to the concept of "mathematics learning" using metaphor techniques. The prospective teachers who participated in the research (a total of 59) included 35 females and 24 males. The participants were asked to formulate metaphors about "mathematics learning". The metaphors and their justifications were analyzed and eight conceptual categories were determined. For reliability of the research study, expert opinion was sought to confirm whether the metaphorical images given under 8 categories represented one of those conceptual categories. The conceptual categories are learning mathematics as eternity, learning mathematics as playing games, learning mathematics as learning to learn-puzzle, learning mathematics as life, learning mathematics as art, learning mathematics as to live-necessity, learning mathematics as mind and learning mathematics as love.*

Keywords: *Mathematical Competence. Prospective Teachers, Metaphors*

1. INTRODUCTION

People generally consider mathematics as difficult. On the other hand, the concept of "mathematics literacy" is widely used today. It encompasses the processes of an individual's using mathematical thinking and decision making for problem solving and acknowledging and realizing the role that mathematics plays in the world. The European framework for "Key Competences for Lifelong Learning", released by the European Parliament and the Council on 18 December 2006, identifies and defines eight key abilities and the third ability is designated as "mathematical competence and basic competences in science and technology". The term "mathematical competence" means the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday life. It is defined as the ability to use addition, subtraction, multiplication, division and proportion in mental and written calculations in order to solve various problems in everyday situations in this reference framework. What is emphasized here is the process and activity, as well as knowledge. Mathematical competence is defined as the ability and willingness to use mathematical modes of thought (logical and spatial thinking) and presentation (formulas, models, constructs, graphs/ tables) to different degrees. It involves an understanding of mathematical knowledge, numbers, measurements, constructs, basic operations, basic mathematical presentations, mathematical terms, mathematical concepts and the questions that mathematics can answer. An individual in the process of lifelong learning should have the ability to apply basic mathematical principles and processes in everyday situations. In other words, individuals should be able to reason, understand mathematical proof, communicate in mathematical language, and to use appropriate aids. With regard to this, mathematical competence is regarded as one of the main components of lifelong learning and mathematics learning is considered in society as a means of establishing competence.

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The way individuals perceive mathematics and what they think about mathematics learning play a role in their establishing mathematical competence. Schwarzenberger (2000) regards mathematics as a language: "Like English, or Latin, or Chinese, there are certain concepts for which mathematics is particularly well suited: it would be as foolish to attempt to write a love poem in the language of mathematics as to prove the Fundamental Theorem of Algebra using the English language." Manin (2000), on the other hand, argues that language is the basis of all human culture and mathematics is a specific type of linguistic activity. Adler (1991) defines mathematics as pure language and the language of science.

There are many research studies about mathematics learning. Some of these studies are on teachers' views of mathematics education (Cooney&Shealy, 1997; Ernest, 1989; Franke,Fennema, & Carpenter, 1997; Lerman, 2001;Richardson, 1996; Thompson, 1992). Some of them are on the images of mathematics and mathematicians (Goodwin, 2007; Lim, 1999; Nik Azis, 2009; Noyes, 2006; Sterenberg, 2007; Utley&Showalter, 2007). Some other studies are on students' views about mathematics and mathematicians (Atallah, 2003; Howard & Perry, 2005; Picker & Berry, 2000). However, no research study that employs metaphor techniques has been conducted with recently graduated prospective mathematics teachers.

Aim

In the new context of education, the emphasis is on learning instead of teaching. Therefore, there has been a transition from a teacher-based approach to a learner-based one. Pedagogy, curriculum development and the use of pedagogy which contributes to active learning form a basis in learning. In this context, being graduates of the department of Mathematics Teaching, the way prospective teachers perceive mathematics learning becomes significant. Moving from this fact, the aim of this study is to identify prospective mathematics teachers' metaphorical images with respect to the concept of "mathematics learning" using metaphor techniques.

2. METHOD

Metaphor techniques were used for the data collection of this research study, which is qualitative. Metaphor means to explain abstract or complex phenomena with more familiar and conventional expressions. According to Goodman (2003), metaphors enable abstract concepts to take a certain form and render them comprehensible through concrete concepts. Morgan (1998: 14) argues that there is a relationship between the metaphors we formulate and how we apprehend the world, how we think and our point of view. Research studies that employ metaphor analysis techniques do not date back long in Turkey. In her study, Balcı (1999) explored teachers', students' and parents' metaphorical images about school. In his study, Saban (2004) explored prospective teachers' metaphorical images about "teacher". In their studies, Saban, Koçbeker and Saban (2006) investigated prospective teachers' perspectives about the concept of teacher using metaphor analysis.

2.1 Study Group

The study group consists of recently graduated prospective teachers who majored in the senior grade of the programs of Mathematics Education and Elementary Education of Hasan Ali Yücel Faculty of Education in İstanbul University during the academic year of 2012-2013. Demographical features of the study group are provided below. (Table 1)

Table 1. *Frequency and percentage distribution of prospective teachers by gender*

Gender	Frequency (f)	Percentage (%)
Female	35	59,32 %
Male	24	40,68 %
Total	59	100

According to Table 1, prospective teachers who participated in the research (a total of 59) included 35 females and 24 males.

2.2 Data Collection

In this research study, which aimed to explore prospective mathematics teachers' metaphorical images about "mathematics learning" using metaphor techniques, the participants in the study

group were given a form that included the prompt of "learning mathematics is like… because ..." and they were asked to formulate metaphors about "mathematics learning". The metaphors and their justifications were later analyzed and taking into account their common features, the conceptual categories they can be grouped under were determined.

2.3 Data Analysis

The stage of coding and sorting: The metaphors collected from the data were listed in alphabetical order and coded. Each form was given a code. Whether the participants in the study group justified their metaphors or not was analyzed. The forms which included metaphors but failed to give a justification for each metaphor were excluded.

The stage of compiling metaphors: After the elimination of the excluded forms, a total of 48 metaphors were obtained with their justifications. A "sample metaphorical expression" was chosen from the participants' essays in order to represent each metaphor. The metaphors whose justifications had been analyzed were listed by frequency.

The stage of category development: At this stage, categories were created with respect to the formulation of metaphors. How the participants conceptualized the metaphors was analyzed. Each metaphorical image developed by the participants was analyzed in terms of the metaphor topic, the metaphor vehicle and the ground (the relationship between the metaphor topic and the metaphor vehicle). Then according to their perspectives, each metaphor was associated with a certain theme and 8 different conceptual categories were created.

The stage of establishing validity and reliability:

In order to establish reliability of the research study, expert opinion was sought to confirm whether the metaphorical images given under 8 categories represented one of those conceptual categories. Two important processes were carried out in order to ensure validity of the research study: Data analysis process (especially how 8 conceptual categories were attained) was explained in detail. Besides, a sample metaphorical image, which was believed to represent each of 48 metaphors, was compiled and all these metaphorical images were included in the findings section.

The stage of interpreting according to the metaphors formulated: Table-2 was prepared taking into account frequency values of the metaphors formulated. Each metaphor was written in exact words of the participants. Then the metaphors were interpreted and what was lacking, known as wrong or confused about concepts were revealed.

3. FINDINGS

The research findings regarding the metaphors developed by recently graduated prospective mathematics teachers about "mathematics learning" were presented in tables. Later, they were analyzed in subtitles according to the research questions and interpreted.

Table 2. *Metaphors and the Number and Percentage of Students that Represent Those Metaphors*

Metaphor Code	Metaphor Name	f	%	Metaphor Code	Metaphor Name	f	%
1.	Life	5	8,45	25.	Discovering a continent	1	1,69
2.	Playing games	3	5,08	26.	Climbing an eternal ladder	1	1,69
3.	Puzzle	2	3,39	27.	Looking at a different world	1	1,69
4.	Doing art	2	3,39	28.	Learning to live	1	1,69
5.	Labyrinth	2	3,39	29.	Being reborn	1	1,69
6.	Game setting	2	3,39	30.	Ablution	1	1,69
7.	Ocean	2	3,39	31.	Wandering in space	1	1,69
8.	Learning a language	1	1,69	32.	Lifestyle	1	1,69
9.	Learning the human kind	1	1,69	33.	Knowing Something unknown	1	1,69
10.	Resisting	1	1,69	34.	Treasure hunt	1	1,69

11.	Soil	1	1,69	35.	Dancing "horon"	1	1,69
12.	Planting trees	1	1,69	36.	Architecture in mind	1	1,69
13.	Achieving the goal	1	1,69	37.	Platonic love	1	1,69
14.	Understanding life	1	1,69	38.	To live	1	1,69
15.	Dreaming	1	1,69	39.	Sailing towards a new world	1	1,69
16.	Machine	1	1,69	40.	Swimming in the sea	1	1,69
17.	Knowing about nature	1	1,69	41.	Journey to the horizon	1	1,69
18.	Water	1	1,69	42.	Travelling to other realms	1	1,69
19.	Air	1	1,69	43.	Learning to learn	1	1,69
20.	Knitting	1	1,69	44.	Meaning of the universe	1	1,69
21.	Doing sports	1	1,69	45.	Loving unconditionally	1	1,69
22.	Remedy for solitude	1	1,69	46.	Discovery	1	1,69
23.	Sudoku	1	1,69	47.	Human lifespan	1	1,69
24.	Making a cake	1	1,69	48.	A captain's love for sea	1	1,69
TOTAL						59	100

1. What metaphors do prospective teachers have about the concept of "mathematics learning"?

In Table 2, the metaphors developed by prospective teachers about mathematics learning were presented in terms of frequency. They produced a total of 48 metaphors. However, the number of metaphors formulated at more than one frequency is 18.

2. The categories of metaphors that prospective teachers have about the concept of "mathematics learning"

In accordance with the data obtained from the study group, the metaphors that have common features in terms of their justifications were grouped together and each group formed a category. Accordingly, the number of categories created in this study is 8.

Table 3. *The Categories of Metaphors Developed with Respect to the Concept of "Mathematics Learning"*

Categories	**Metaphors**	**Frequency of Metaphor**	**Number of Metaphor**
1.Eternity	Doing Sports (F1), Ocean (F2, F9), Climbing an eternal ladder (F31), Wandering in space (M37), Endless Activity (M39), Treasure Hunt (M40), Traveling to Other Realms (M52)	8	7
2. Playing Games	Game setting (F26, F28), Playing games (F15, F16, F29), Dancing "horon" with numbers (M41)	6	3
3. Learning to learn-Puzzle	Dreaming (F3), Solving Sudoku puzzles (F4), Labyrinth (F6, F30), Planting trees (F13), Achieving the goal (F14), Puzzle (F17, M42), Water (F19), Knitting (F21), Learning to learn (M53), Human Lifespan (M57), A new discovery (M56)	13	11
4.Life	Understanding life (F7), Soil (F12), Knowing about nature (F18),	12	8

	Learning the human kind (F10), Learning to live (F33), To live (M47), Life (F22, F35, M44, M45, M58), Meaning of the universe (M54)		
5. Art	Doing art with numbers (F24), Making a cake (F25), Art (M48)	3	3
6. To live-Necessity	Learning a language (F8), Air (F20), Discovering a continent (F27), Ablution (M36), Lifestyle (M38)	5	5
7. Mind	Functioning of a machine (F5), Resisting (F11), Remedy for solitude (F23), Looking at a different world (F32), Being reborn (F34), Architecture in mind (M43), Sailing towards a new world (M49), Swimming in the sea (M50), Journey to the horizon (M51)	9	9
8. Love	Platonic love (M46), Loving unconditionally (M55), A captain's love for sea (M59)	3	3

Conceptual Categories

1. ***Learning mathematics as Eternity:*** This category is represented by 8 prospective teachers and 7 metaphors (see Table 3). This category includes Doing Sports (F1), Ocean (F2, F9), Climbing an eternal ladder (F31), Wandering in space (M37), Endless Activity (M39), Treasure Hunt (M40), Traveling to Other Realms (M52). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"You might not want to learn it at first, but as you learn it, you will start to see its benefits and want to learn more. It is infinite." (F1)*
- *"Because it is infinite. No matter how much you learn, there is still a lot to learn. There is no end to learning" (F2)*
- *"It is endless. It is infinite. We always try to get somewhere. We get there, but there is always further beyond. " (M37)*
- *"You can go into as deep as you want." (M40)*
- *"Mathematics is full of endless obscurity. It is like discovering the unknown, travelling with sense of wonder and discovering new things every time you travel. And it is like using these new things to solve the problems we face in every journey." (M52)*

2. ***Learning mathematics as Playing Games:*** This category is represented by 6 prospective teachers and 3 metaphors (see Table 3). This category involves Game setting (F26, F28), Playing games (F15, F16, F29), Dancing "horon" with numbers (M41). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"Everything you learn prepares you for a next level. Just like playing next levels of a game. You cannot skip over a subject before you learn it. Just like you cannot play the next level of a game before you finish the previous one." (F28)*
- *You can only win after you test it with different strategies. (F15)*
- *"It is like meeting with numbers in an abstract world and playing games with them, tackling with them, having fun with them and enjoying the life to the full extent. (F16)*
- *"You can play games with numbers in mathematics." (M41)*

3. ***Learning mathematics as Learning to learn-Puzzle:*** This category is represented by 13 prospective teachers and 11 metaphors (see Table 3). This category involves Dreaming (F3), Solving Sudoku puzzles (F4), Labyrinth (F6, F30), Planting trees (F13), Achieving the goal (F14), Puzzle (F17, M42), Water (F19), Knitting (F21), Learning to learn (M53), human lifespan (M57)

and a new discovery (M56). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"In mathematics, new knowledge always builds on old knowledge. They are in a two-way relationship." (F6)*
- *"Each thing you learn is a piece of puzzle. As you learn new things, puzzle pieces complement each other. Finally, you get a very nice unity." (F17)*
- *"As you drink it, you want to drink more. In mathematics, people try to put into practice the right things they have learnt. Knowledge brings about new knowledge. Therefore, we can make generalisations out of various knowledge and create distinctive formulas. That urges people more to deal with mathematics. The knowledge we learn builds up and reaches generalisations and theorems. That is why I resembled it to water. As water increases, it rises. Water is indispensable, and so is mathematics." (F19).*
- *"It's both enjoyable and fun, but learning something falsely can ruin everything." (F21)*
- *"Mathematics is such a science, discipline and way of thinking that everything you learn in mathematics is a prerequisite to new knowledge and a horizon. Every knowledge you have learned is followed by new knowledge. Knowledge comes about constantly…" (M53)*
- *"To begin with, love for mathematics is a hidden love of a human. Just like a baby waiting in a mother's abdomen. Then babyhood, when first revealed, is a very nice thing. As you learn new things about mathematics, that is, about life, it gets even nicer." (M57)*

4. Learning Mathematics as Life*:* This category is represented by 12 prospective teachers and 8 metaphors (see Table 3). This category involves Understanding life (F7), Soil (F12), Knowing about nature (F18), Learning the human kind (F10), Learning to live (F33), To live (M47), Life (F22, F35, M44, M45, M58), Meaning of the universe (M54). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"Mathematics helps understand nature and life better. On the other hand, nature is established on a mathematical system. Learning mathematics helps us understand life better." (F7)*
- *"Just as life is impossible without soil, many things are incomplete without mathematics. Just as plant life depends on soil, the maintenance of human life depends on mathematics." (F12)*
- *"There is a lot to learn in life. To learn mathematics takes hard work. Life is worth living and mathematics is worth learning." (F35)*
- *"Learning mathematics enables us to look at life more meaningfully and critically. It provides us with different perspectives. It enables us to understand other people and empathise with them." (M44)*
- *"We face mathematics in every field of life. Mathematics is life. We see mathematics in every job we do in daily life. Mathematics makes great contribution to our lives. It might shape the way we look at life." (M45)*

5. *Learning mathematics as Art:* This category is represented by 3 prospective teachers and 3 metaphors (see Table 3). This category involves Doing art with numbers (F24), Making a cake (F25) and Art (M48). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"It is an art of attributing a meaning to numbers and using and mastering them as you wish." (F24)*
- *"At first, there is only ingredients, that is, the numbers. As these numbers unite, you get a cake mixture. When you bake the cake, the level of comprehension increases. When you decorate it with the cream, it becomes fun. When you see the whole job, it is like a perfect work of art." (F25)*

- *"You do art with numbers. Mathematics is like music, it's harmonious." (M48)*

6. Learning mathematics as To Live-Necessity*:* This category is represented by 5 prospective teachers and 5 metaphors (see Table 3). This category involves Learning a language (F8), Air (F20), Discovering a continent (F27), Ablution (M36) and Lifestyle (M38). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"There is a famous saying: Mathematics is the language of the universe. The universe needs a language in order to communicate with us. And as a language, it has chosen mathematics, which people have difficulty to understand. For example, when the values regarding air current are high, we infer that something is not going right. The fact that it can talk to us is great." (F8)*
- *"Even if we do not sense it, we know that it exists. In order to understand whether it exists or not, we need to comprehend logical relationships. If air doesn't exist, there is no fire, water or soil. Just like air is the reason for the existence of all elements, mathematics is the reason for the existence of all sciences. Mathematics enables us to explain all logical relationships." (F20)*
- *"When you forget it, it ruins. You need to transfer it from generation to generation. Mathematics cleans the soul like ablution does and leads human to the goodness. You need to know about science in order to do it. Therefore, it is essential to learn mathematics." (M36)*
- *"Mathematics has its own rules, restrictions and hardships like lifestyles do. Just like life, mathematics starts from the easy and simple. It progresses level by level. It puts barriers in the way, but it takes time and ways out to eliminate these barriers and solve problems." (M38)*

7. *Learning Mathematics as Mind:* This category is represented by 9 prospective teachers and 5 metaphors (see Table 3). This category involves Functioning of a machine (F5), Resisting (F11), Remedy for solitude (F23), Looking at a different world (F32), Being reborn (F34), Architecture in mind (F43), Sailing towards a new world (M49), Swimming in the sea (M50), Journey to the horizon (M51). Examples of prospective teachers' expressions that belong to this category are povided below:

- *"Mathematics and mind complete each other, they help each other, and they constantly make the brain work. If the machine does not function, it gets rusty. So does the mind. " (F5)*
- *"You neither feel alone nor get lonely. There is always something you think about in your mind and you feel it more when you think about it." (F23)*
- *"Mathematics is abstract, not concrete. It means using the brain in order to think differently and constructing buildings in mind. You can build new buildings upon those buildings." (M43)*
- *"For anyone who knows mathematics, it is wide as sea and enhoyable as you can swim in it. However, if one does not know mathematics, he has a point of view of someone who does not know how to swim. Therefore, sea is a frightening well." (M51)*

8. *Learning Mathematics as Love:* This category is represented by 3 prospective teachers and 3 metaphors (see Table 3). This category involves Platonic love (M46), Loving unconditionally (M55) and A captain's love for sea (M59). Examples of prospective teachers' expressions that belong to this category are provided below:

- *"No matter how much you love it, it will not love you, not at all. It is always you that has to love it. It has no privilege such as loving you. You have to chase it, it won't chase you. It gets complicated as you love it." (M46)*
- *"Everyone can maintain a mutual relationship. However, it is true lovers that maintain an unrequited relationship. Mathematics is a castle that does not open its gates easily*

even if you put a lot of effort. When you give 10, mathematics gives you 1. And those who love this poverty love mathematics, too." (M55)

- *"Once you enjoy mathematics, you will always want to enjoy the taste of it. This will continue for a lifetime. A captain's love, peace and happiness when he sails to the sea resemble to a growing desire to solve problems. All in all, as you get there, the voyage drags on." (M59)*

4. CONCLUSION AND DISCUSSION

This research study was conducted to explore prospective teachers' perceptions about the concept of "mathematics learning" using their metaphorical images and to group these metaphors under conceptual categories.

According to the research results, 59 prospective teachers in the study group produced a total of 48 metaphors. Prospective mathematics teachers used metaphors such as "ocean", "labyrinth", "playing games", "game", "life", "puzzle", "doing art" about the concept of "mathematics learning". As suggested by Weade and Ernst (1990), "Metaphors are selective. They represent a part, but not the whole, of the phenomena they describe.'' In this context, it can be said that many metaphors are required to explain the concept of "mathematics learning".

When we categorize prospective mathematics teachers' metaphors about "mathematics learning", the category that involves the most number (11) of metaphors is "learning to learn-puzzle" and 22% of the study group is represented in this category. This category is followed by the category of "life". Prospective teachers produced 8 metaphors in this category and 21% of the study group is represented in this category. 7 metaphors produced by prospective mathematics teachers are included in the category of "eternity" and 13,6% of prospective teachers is represented in this category. The categories that involve the least number (3) of metaphors are "art" and "love".

In line with these findings, it is seen that prospective mathematics teachers evaluate their metaphors in different dimensions. When both the metaphors and conceptul categories are studied, it is observed that prospective teachers attach importance to the dimension of vitality and profoundness of mathematics learning.

Taking into consideration these research results, the following suggestions can be provided for further research and researchers:

- This research is limited to prospective mathematics teachers that studied in the faculty of education in İstanbul. A similar research study can be conducted with a larger study sample.
- Different techniques such as verbal data can be used to analyze the relationship between the metaphors and mathematics learning in a more detailed way.
- Similar researches can be conducted with respect to the metaphors about mathematics learning and teaching or about something else.
- This research study was conducted with prospective mathematics teachers. Similar researches can be conducted with parents, administrators, students and prospective teachers.

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