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Pre-service Mathematics Teachers and Undergraduate Mathematics Students' Metaphorical Perceptions of the Concept of Mathematics*

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***Abstract*:** This study aims to compare the metaphors developed by the students of the Pre-service Mathematics Teachers (PMT) and the students of the Undergraduate Mathematics (UM) regarding the concept of mathematics and to determine how the metaphors are distributed as to the variables level of class and the department. For this purpose, hermeneutic phenomenology was used as a type of phenomenology design- one of the qualitative research methods. This study was conducted during the 2021/22 academic year with a total of 57 UM students studying at the Faculty of Arts and Sciences of a public university in the Southeastern Anatolia Region, and a total of 68 PMT students studying at the Faculty of Education at the same university. Data was collected through an interview form and analysed with content analysis. It was concluded that many metaphors are necessary in order to explain the concept of mathematics in a holistic way and that the respondents considered mathematics with its positive and negative aspects, as well as embracing it in daily life. It was also observed that the respondents' perceptions of mathematics differ depending on the level of class and the department. For example, while the PMT students approached mathematics with a more concrete viewpoint, the UM students adopted an abstract mind-set. The reason for this result is believed to be related to the fact that the curricula applied for the PMT students contains less abstract expressions and theoretical lessons than that of the UM students, and also makes students active, offers a constructivist learning environment, and aims to train mathematics teachers rather than training them to become mathematicians.
Keywords: Metaphor, Mathematics education, Phenomenology, Pre-service mathematics teachers, Undergraduate mathematics.

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Introduction

Throughout history, humanity has defined mathematics in many different ways according to the problems of its age. Although mathematics was once defined as "something to be learned", it still referred to many other things, varying from the necessity of measuring due to the Nile's flooding, to counting and specifying quantities in line with needs (Başıbüyük, 2018), a collection of numbers and operations together with operational calculations (Toluk, 2003), a system that prompts people to think logically through generalizations in daily life (Baykul, 1999), a tool to overcome the difficulties encountered (Altun, 2001), and a thinking activity used to come up with a solution to a problem (Altun, 2008). Today, the relevant literature has failed to answer the question: "What is mathematics?" However, Göker (1997) provided more than one explanation as an answer to this question, though it has been regarded that there is no single answer to such a question (Nasibov & Kaçar, 2005). From this standpoint, it can be argued that mathematics is generally life itself and an abstract branch of science. However, due to being an abstract branch of science, mathematics can be perceived by students as a boring subject (Uçar et al., 2010; Çalışıcı & Sümen, 2019), which is also disliked and avoided (Yetim Karaca & Ada, 2018), and challenging (Dede & Argün, 2004). In addition to the implications developed specific to mathematics, environmental experience and the attitudes and beliefs of the educators are also likely to be influential on such perceptions of students (Uçar et al., 2010; Yetim Karaca & Ada, 2018). In this sense, educators should be aware of their impact on students and act accordingly (Uçar et al., 2010).

The relationship between teachers and students plays a critical role in the positive or negative behaviour of students in lessons (Yetim Karaca & Ada, 2018). Considering this issue in relation to mathematics lessons, it is essential that teachers, in particular, should have a positive attitude, since they play a significant role in developing positive attitudes towards mathematics as a subject (Çalışıcı & Sümen, 2019). It is also known that the attitudes of educators in departments where mathematicians are trained exert a great impact on students' perceptions of mathematics. For this reason, determining the perceptions, beliefs and tendencies of prospective teachers and students of the Undergraduate Mathematics throughout their education process is likely to positively affect their professional development (Noyes, 2004). In this connection, metaphors are often used to identify these perceptions and to identify the underlying factors (Ben-Peretz et al., 2003).

More than one definition of the concept of metaphor is present in the literature. As an example, while the concept of metaphor is referred to as "simile" according to the Turkish Language Association (TLA, 2022), Saban (2004) defines metaphors as a powerful mental tool that shapes an individual's opinions in the face of a plot. In addition, there are many other definitions such as a way of thinking that expands individuals' horizons by making them look at life from different perspectives (Morgan, 1998), as well as a way of making sense of a phenomenon depending on another phenomenon (Lakoff & Johnson, 2005), enabling a transfer from the known to the unknown (Soysal & Afacan, 2012), and helping individuals understand the world (Güler et al., 2011). As stated by Cassel and Vincent (2011), metaphors are an important tool for constructing meaning rather than searching for it. From this standpoint, it is believed that the use of metaphors is necessary to determine how the students of the Pre-service Mathematics Teachers, who are trained to become mathematics teachers, and the students of the Undergraduate Mathematics, who are trained to become mathematicians, construct meanings for the phenomenon of mathematics and on which basis they make sense of it.

Literature Review

Research has shown that studies conducted on metaphors developed for the concept of mathematics have two aspects: (1) determine how participants use metaphors in the construction of mathematical phenomena (Lakoff & Nuñez, 2000; Danesi, 2007; Sinclair & Tabaghi, 2010; Font et al., 2010; Zandieh et al., 2017), and (2) focus on metaphors used as a tool to determine how participants construe mathematics as an entity (Cassel & Vincent, 2011; Latterell & Wilson, 2016; Soto-Johnson et al., 2016; Olsen et al., 2020; Smith et al., 2023). As an example, Sinclair and Tabaghi (2010) aimed to determine how mathematical abstractions made by mathematicians on the concept of eigenvector are construed by using metaphors in mathematical language. One of the participants, used the metaphor of elastic band to represent the stretching of eigenvectors. In another study, researchers (Font et al., 2010) investigated how teachers used metaphors in the process of reading the Cartesian graphs in relation to functions. As a result of that study, teachers turned out to have chosen to use conceptual metaphors, in general, in teaching the subject of function; and an example of conceptual metaphors used in the study was that the graph was associated with the road metaphor.

The relevant literature review pointed to some other studies conducted mostly with students (Schinck et al., 2008; Sezgin Memnun, 2015; Markovits & Forgasz, 2017; Yetim Karaca & Ada, 2018; Koçak & Bilecik, 2019) and prospective teachers (Reeder et al., 2009; Cassel & Vincent, 2011; Tarım et al., 2017; Kuzu et al., 2018). Kuzu et al. (2018), for example, aimed to determine the perceptions of prospective teachers in different branches of teaching as regards mathematics and through which metaphors they conveyed such perceptions. As a result of the study, the students' perceptions towards mathematics were found to differ depending on their department of study, and in fact, the attitudes of the prospective mathematics teachers were found to be more positive than the attitudes of those in other departments, whereas the attitudes of the prospective Turkish teachers were found weaker than those of the students in other departments. In another study, researchers (Markovits & Forgasz, 2017) asked primary school students to create metaphors for the concept of mathematics and used such metaphors to understand students' attitudes towards mathematics. For example, one of the participants using the metaphor of a lion emphasized that mathematics can be achieved by smart people. Another participant used the metaphor of a bird while suggesting that mathematics cannot be learned without effort and struggle. Furthermore, Markovits and Forgasz (2017) associated lion and similar metaphors with wisdom, but bird and similar metaphors with the teaching process of mathematics.

From a perspective which has never been emphasized in the relevant literature, this study has made use of metaphors as a tool to compare the mathematics-related perceptions of the students, with a similar mathematical background, the Pre-service Mathematics Teachers (PMT) and taking a course on how mathematics should be taught, as well as those students of the Undergraduate Mathematics (UM), who were studying advanced mathematics. In view of this, the present study has two main purposes. The first goal is to determine the discourses of PMT and UM about the phenomenon of mathematics and carry out an examination with respect to the development process of courses so as to contribute to the literature. Another goal of ours is to examine how the experiences in mathematics lessons, which play a significant role in shaping students' perceptions of mathematics will create differences for students from different departments with similar mathematical backgrounds. To this end, answers were sought to the following research problems:

- What is the metaphorical perception of the concept of mathematics of pre-service (prospective) mathematics teachers and undergraduate mathematics students?
- Do students' metaphorical perceptions of the concept of mathematics vary according to their level of class and the department in which they study?

Method

With the aim of exploring and comparing the metaphors developed by the students of the Pre-service Mathematics Teachers and those of the Undergraduate Mathematics regarding the concept of mathematics, this study an in-depth analysis (Patton, 2002, p. 28) and employed a qualitative research method to obtain rich data (Strauss & Corbin, 1998, p. 40).

Research Design

Hermeneutic (interpretive) phenomenology was used in this study as a type of phenomenology design, with the aim of defining the essence of the mathematics subject in terms of the experiencer of the phenomenon (Teherani et al., 2015). This type of phenomenology is concerned with how individuals' experiences through life and the meanings they attribute to such experiences affect their preferences (Laverty, 2003). In this connection, this study examined the relationship between the metaphors that the students developed for mathematics and their explanations for such metaphors depending on their department of study, and likewise, the metaphors were then interpreted in the same context (Heidegger, 1867; as cited in Neubauer et al., 2019).

Participants

Considering the research design, it is clear that the participants should have a homogeneous structure (Creswell, 1998). For this reason, utmost attention was paid to the formation of the study sample so that it would consist of people who had similar and meaningful experiences with mathematics, and the purposive sampling method was used. Table 1 presents the descriptive statistics of the participants.

Table 1
Data about the participants

	PMT		UM		Total
Class	Female	Male	Female	Male	F+M
Class 1	31	13	26	12	82
Class 2	19	5	14	5	43
Total	50	18	40	17	125

Data Collection

Data was collected through an interview form consisting of open-ended questions prepared after the opinions of three faculty members in the field of Mathematics Education were taken, and by using a number of metaphors collected in different studies in the literature (i.e., Mahlios & Maxson, 1998; Carlson, 2001; Saban, 2003; Güveli et al., 2011). In the interview form, the participants were asked to fill in the blanks given as "Mathematics is like the colour… / similar to the colour… (or food, vehicle, season)" and to explain the reasons for their answers. Before the interview forms were presented, volunteer students were given the "Informed Consent Form for the Respondents" and were asked to abide by the instructions.

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Data Analysis

A total of four stages were used for the analysis of the metaphors developed by the participants in the study sample for the concept of mathematics.

Data Coding and Extraction Phase

In the first stage, the researcher entered the answers given by the respondents into an Excel file in a temporary order, after which, the answers were analysed. At this stage, some of the forms were excluded from the analysis process since they contained answers indicating no logical relationship between the metaphor itself and the subject of the metaphor, such as "*Mathematics is like the colour brown as it reminds me of brown*", or "*Mathematics is like Adana kebab because I am from Adana*", and those forms of the participants who apparently misread the metaphor of "vehicle" (i.e., taşıt in Turkish) as "stone" (i.e., taş in Turkish) and presented the metaphors of "diamond, touchstone, and gravel" as answers, as well as those forms with the questions left unanswered (20). In the coding process, a process was followed in which the departments, level of class, genders and student numbers of the participants in the classroom list were taken into account. As an example, the 8th female student studying in the 2nd class of the Pre-service Mathematics Teachers was given the code "PMT2F8", and the 4th male student studying in the 1st class of the Undergraduate Mathematics was coded as "UM1M4". Table 2 presents the distribution of the participants according to their department of study at the end of the coding and sorting phase.

Table 2
The participants at the end of the selection process

	PMT		UM		Total
Class	Female	Male	Female	Male	F+M
Class 1	27	10	22	11	70
Class 2	17	3	11	4	35
Total	44	13	33	15	105

A Sample Metaphor Compilation Stage

The participants' responses, which after the sorting and coding phase, were divided into four parts as PMT1, UM1, PMT2 and UM2, respectively. At this stage, the answers given by the participants within the context of the metaphors of colours, foods, vehicles, and seasons were evaluated as the source of the metaphor and also listed alphabetically within their own sections. Then, the frequency distributions were obtained for each metaphor among the listed metaphor sources, which were then demonstrated in tables separately for the four sections together with their explanations. These tables can be taken as a reference in the process of determining the themes under which the metaphors were gathered.

Category Development Stage

At this stage, content analysis was used and the source of the metaphor (itself) was examined in the way suggested by the participants in terms of the subject of the metaphor (explanations) through the tables formed during the sample metaphor compilation stage. Next, the subjects of metaphors with a certain common feature were gathered under 18 similar draft themes. However, the fact that having a small number of themes allows for deeper abstraction (Merriam, 2009/2018, p. 179), the draft themes were revised and rearranged to come up with main themes and sub-themes. An example of this process is given in Table 3.

Table 3
Themes derived from the source-subject relationship of metaphors

Theme	Sub-themes	Description	Colour	Food	Vehicle
Embedded in life	Basis of life	Mathematics is the building block of life and science	*It is the same colour as the sun. Science needs mathematics just as the Earth needs the Sun* (PMT1F9).	*It is like protein, there is no life without mathematics* (UM1M11).	*...like a public transport vehicle, which everyone tries to get on and what everyone really needs* (PMT1M9).
	Everywhere in life	Mathematics is comprehensive and involved in every field	*It contains all colours. Mathematics is everywhere in daily life* (PMT1M3).	*Bread is always eaten with every meal. Mathematics is also used in most parts of our lives* (UM2M1).	*It exists throughout our lives and affects everyone* (PMT1M2).

The Stage of Ensuring Validity and Reliability

The triangulation analysis strategy (Patton, 2000, p. 560) was used to ensure the internal validity of the research. In this context, the researcher and a lecturer actively working in the field of Mathematics Education conducted the data analysis process independently of each other and compared the results of the analysis. In addition, another strategy called participant validation (Merriam, 2009/2018, p. 207) was used to ensure internal validity. In line with this strategy, five participants were accessed to share the findings with and to ask for their feedback. In order to ensure the external validity of the study, the participants were given names and the entire data analysis process was explained in detail, and then the results were reported in depth and compared with the studies in the literature.

For the reliability of a phenomenological study, the most frequently used strategies are determining the researcher bias, confirming the findings by the participants, and calculating the inter-coder reliability (Creswell, 2013, p. 250-253). In addition to this, it is necessary to determine the role of the researcher in the study in order to eliminate researcher bias (Creswell, 2013, p. 251). In this study, the researcher is responsible for applying the data collection tool, conducting data analysis, interpreting the findings in depth, and discussing the results obtained with reference to the literature. The process of verifying the findings by the participants was presented in the section about the internal validity, and hence, in this stage, expert opinion was obtained and the inter-coder reliability was calculated. An active faculty member in the field of Mathematics Education opinion was sought in order to confirm the themes prepared based on the relationship between the source of the metaphors and the subject of the metaphors. At the end of this process, the feedback from the expert and the themes created by the researcher were compared and the calculation was made with the following formula (1), developed by Miles and Huberman (1994, p. 64):

$$\text{Reliability} = \frac{\text{Number of Agreement}}{\text{Number of agreements} + \text{Number of disagreements}} \quad (1)$$

According to Miles and Huberman (1994, p. 64), a result of 90% or more is considered sufficient in this formula. As a result of the comparison, the reliability was found to be 0.95 (95%) (Reliability = 399 / (399+21) = 0.95 (95%)).

Results

Students' Perceptions of the Concept of Mathematics by Four Metaphors

Figure 1, Figure 2, Figure 3, and Figure 4 present the findings in relation to the metaphors of colours, foods, vehicles, and seasons that best represent (most preferred) the perceptions of the UM students and PMT students about the concept of mathematics.

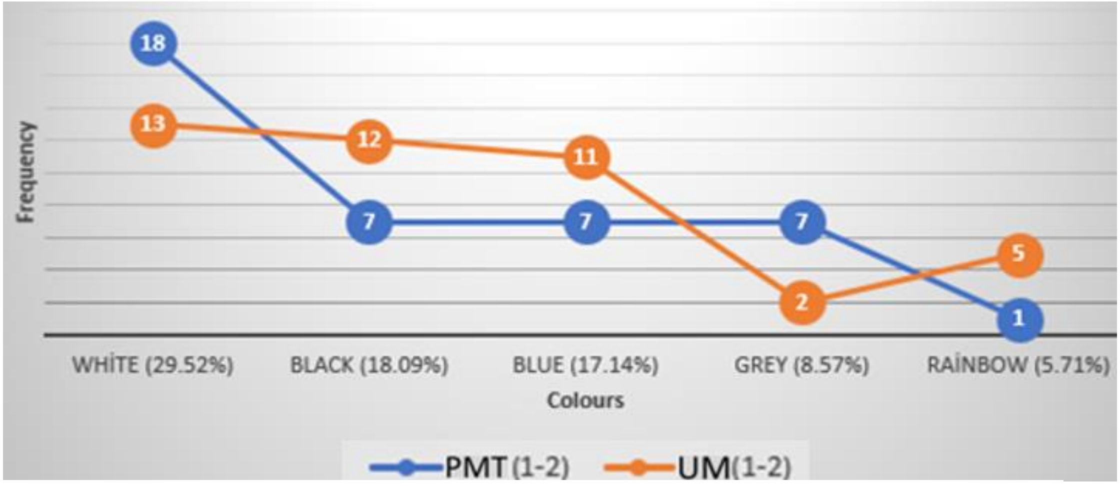

Fig. 1 Perceptions of PMT and UM students about Mathematics by the colour they choose

In a general sense, the students seemed to have referred to the colour white to state that mathematics is an interdisciplinary course that plays a critical role in all areas of life and contains no doubt. They also seemed to have associated their negative feelings towards mathematics with the colour black. As an example, they used the metaphor of the colour black to indicate that mathematics is a difficult subject. With the colour blue, on the other hand, they appeared to have addressed mathematics as an indefinite and endless set of knowledge. In addition, one of the students referred to mathematics as the colour of life by saying "*…because it is a lesson that connects you to life as you keep studying* (PMT2K10)", adding that mathematics can be considered a factor for connecting to life, while another student likened mathematics to the colour of a chessboard and said: "*…it is sometimes dark and sometimes bright* (PMT2K5)", emphasizing the fact that mathematics consists of contrasts.

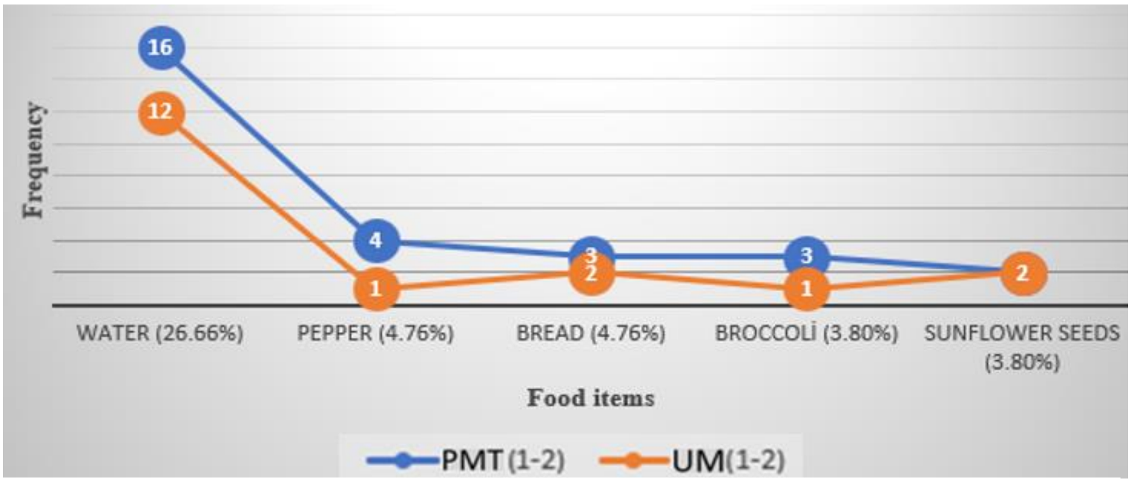

Fig. 2 Perceptions of PMT and UM students about mathematics in terms of food items selected as metaphors

It can be clearly seen that the students generally considered water and mathematics as the source of life and science. Moreover, they used the metaphor of bread to state that mathematics is the complement of other courses and the metaphor of sunflower seeds to stress the addictive feature of mathematics. While asserting that mathematics tends to hold opposites together, the students used the metaphors of pepper and broccoli. In addition, some students likened mathematics to carbohydrates by saying, "*...it is everywhere* (UM1E5)", while some similized it to protein and said, "*... because protein acts like the building block of the body, and so does mathematics to science* (UM2K4)". While comparing mathematics to fatty food, it can be concluded that the students emphasized that mathematics exists in all areas of life and that it is useful, by stating that "*...the body stores the fatty food to use it later, and likewise, we store and use information in mathematics* (UM2K10)".

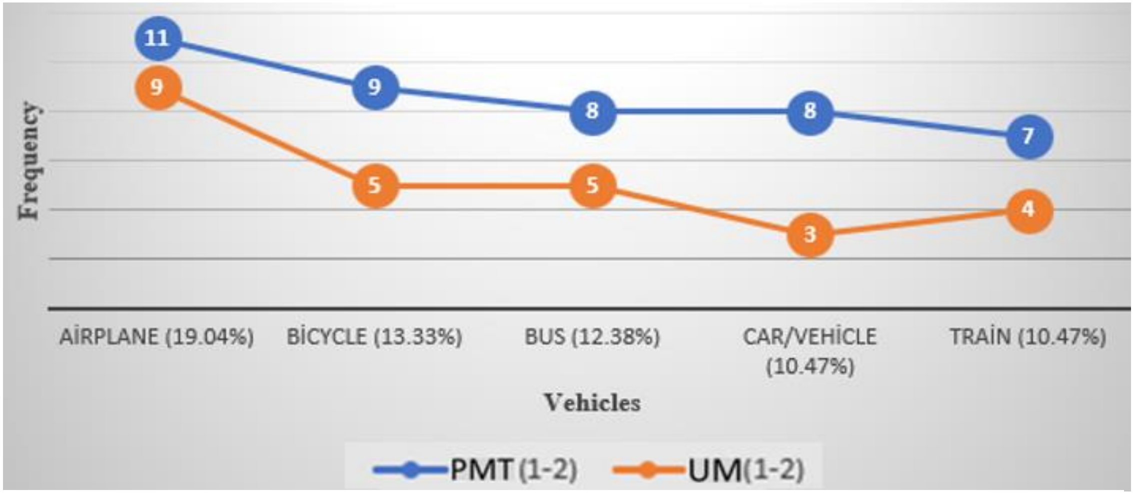

Fig. 3 Perceptions of PMT and UM students about mathematics in terms of vehicles selected as metaphors

It has also been observed in this study that the students generally emphasized the developmental aspect of mathematics with the airplane analogy, stating that mathematics brings you success, and with the bicycle analogy, they stressed that mathematics is a demanding course. The students also seemed to have associated the metaphor of the bus with the fact that mathematics is a time-consuming lesson despite the systematic continuation of it. They further emphasized the usefulness of mathematics with the analogy of a car, considering it as a lesson that not everyone could be interested in. In addition, while the students stated that mathematics consists of many subjects, they turned out to prefer using the analogy of a train. In addition, some students similized mathematics to a horse carriage, saying that "*...we can go through the topics and questions slowly and step by step* (PMT1K16)", "*...if you do not lead the horse, the carriage will not move. So, the horse must be taught how to ride on the road. No progress can be made without learning* (UM1K1)", "*... a horse will not go without us telling them 'Giddy up'* (UM1K9)". Thus, it can be considered that the students emphasized that mathematics is a course that can be achieved over time and is necessary to learn.

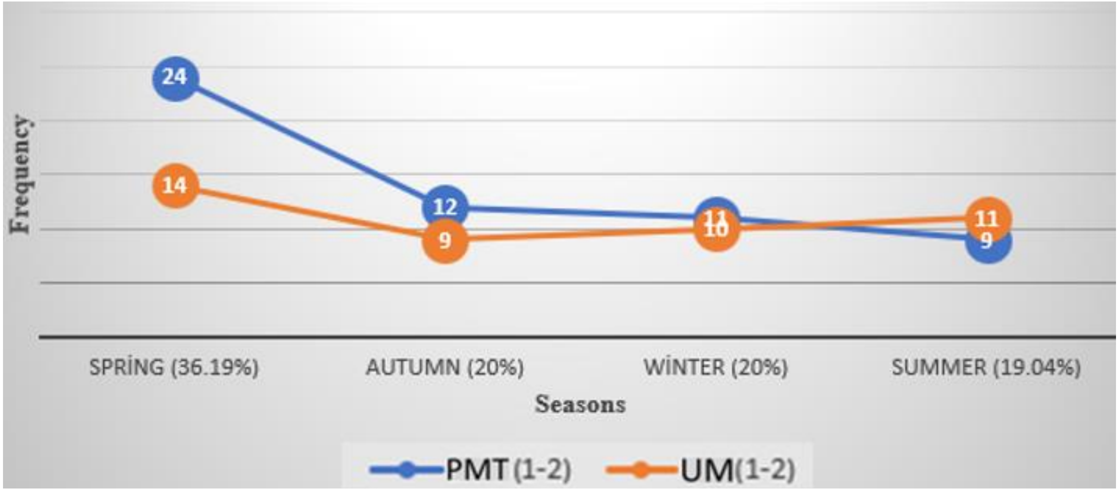

Fig. 4 Perceptions of PMT and UM students about mathematics in terms of seasons selected as metaphors

It is also clear that the students who referred to the allegory of the spring were generally of the opinion that mathematics requires effort, but that this effort is surely rewarded when they work. Also, the students seemed to associate their negative feelings towards mathematics with autumn and winter seasons. As an example, the fact that mathematics is a difficult lesson to understand was expressed with the metaphor of the autumn, and that it is a lesson that not everyone likes due to its difficulties was expressed with the metaphor of the winter. On the other hand, the students suggested that mathematics contains positive emotions against the occurrence of some challenges in mathematics by using the allegory of summer. In addition, some students likened mathematics to the four seasons, saying that "*...mathematics covers everything, with its pluses and minuses, like the four seasons* (PMT1K5)", "*...it is like hearing a ringing sound in your brain and experiencing enlightenment at a point where you think you do not understand, or realizing that you have no idea about anything just when you are thinking that you have understood something* (UM2K2)", "*...mathematics needs something on every subject. Even if you get into trouble, it still goes around and never gives up on loving you and never lets you give up* (UM2K5)". By making these explanations, it can be asserted that they emphasized the comprehensive, incomprehensible and indispensable nature of mathematics.

Differences Between the Themes by Level of Class and the Department

Based on the purpose of determining the participants' perceptions of the concept of mathematics, Table 4 and Table 5 present the comparisons in terms of level of class and the department for the themes created through the four metaphors.

Table 4
Frequency of themes by the level of class

Themes	Sub-themes	Description	F PMT1	PMT2	UM1	UM2	Total (f)	Perc. (%)
Embedded in life	Basis of life	Mathematics as the building block of life and science	14	11	9	9	73	17.38
	Everywhere in life	Mathematics as comprehensive and being involved in every field	11	3	10	6		
Valuable	Affective	A useful and favourite subject	28	17	25	12	97	23.09
	Person-dependent	Approaching from different angles	2	0	0	1		
	Addictive	Triggers the desire to constantly learn	4	3	4	1		
Relatable	Contains many topics	Composed of many topics	5	4	9	0	31	7.38
	Interdisciplinary	Being associated with other sciences	5	5	1	2		
Holds the opposites together	Variable	Linking positives and negatives	35	16	27	5	83	19.76
Immutable and systematic	Clear	Clear and provable	3	2	4	6	30	7.14
	Has an algorithm	Systematic	7	1	3	4		
Infinite	Endless knowledge	No limits to mathematical knowledge	2	3	8	6	19	4.52
Developmental	Self-renewing	Open to development and generating new ideas	0	1	2	3	6	1.42
Hard to comprehend	Deep	Going into detail for understanding	5	3	4	1	13	3.09
Effortful	Labour and patience	Effortful and patience to achieve success	7	2	6	0	15	3.57
Distressing	Achievable only by those who are capable	Not achievable by everyone	7	0	10	0	53	12.61
	Challenging and boring	Unpopular and boring	13	9	10	4		

As can be seen in Table 4, when compared to the 2nd class PMT students, the 1st class PMT students seem to have associated mathematics more with the following themes: “holding the opposites together (23.64%-20%)”, “immutable and systematic (6.75%-3.75%)”, “effortful (4.72%-2.5%)”, and “distressing (13.51%-11.25%)”, while they appeared to have addressed the following themes less frequently: being “embedded in life (16.89%-17.5%)”, “valuable (22.97%-25%)”, “relatable (6.75%-11.25%)”, “infinite (1.35-3.75%)”, “developmental (0%-1.25%)”, and “hard to comprehend (3.37%-3.75%)”. And likewise, when compared to the 2nd class UM students, the 1st class UM students seem to have associated mathematics more with the following themes: being “relatable” (7.57%-3.33%), “holding the opposites together (20.45%-8.33%)”, “hard to comprehend” (3.03% - 1.66%), “effortful (4.54%-0%)”, and “distressing (15.15%-6.66%)”, while they appeared to have addressed the following themes less frequently: being “embedded in life (14.39%-25%)”, “valuable (21.96%-23.33%)”, “immutable and systematic (5.30%-16.66%)”, “infinite (6.06%-10%)”, and “developmental (1.51%-5%)”.

Furthermore, when compared to the 1st class UM students, the 1st class PMT students seemed to have associated mathematics more with the following themes: being “embedded in life (16.89%-14.39%)”, “valuable (22.97%-21.96%)”, holding the opposites together (23.64%-20.45)%)”, “immutable and systematic (6.75%-5.30%)”, and “effortful (4.72%-4.54%)”, while they appeared to have addressed the following themes less frequently: being “relatable (6.75%-7.57%)”, “infinite (1.35-6.06%)”, “developmental (0%-1.51%)”, and “distressing (13.51%-15.15%)”. And similarly, when compared to the 2nd class UM students, the 2nd class PMT students were found to have associated mathematics more with the following themes: being “valuable (25%-23.33%)”, “relatable (11.25%-3.33%)”, “holding the opposites together (20%-8.33%)”, “hard to comprehend (3.75%-1.66%)”, “effortful (2.5%-0%)”, and “distressing (11.25%-6.66%)”, whereas they appeared to have referred to the following themes less frequently: being “embedded in life (17.5%-25%)”, “immutable and systematic (3.75%-16.66%)”, “infinite (3.75%-10%)”, and “developmental (1.25%-5%)”.

When the themes were examined in terms of the students’ level of class, when compared to the 2nd class PMT and UM students, the 1st class PMT and UM students seemed to have associated mathematics more with the themes presented as follows: “holding the opposites (44.10%-28.33%)”, “hard to comprehend (6.40%-5.41%)”, “effortful (9.27%-2.5%)”, and “distressing (28.66%-17.91%)”, whereas they appeared to have referred to the following themes less frequently: being “embedded in life (31.28%-42.5%)”, “valuable (44.94%-48.33%)”, “relatable (14.33%-14.58%)”, “immutable and systematic (12.05%-20.41%)”, “infinite (7.41%-13.75%)”, and “developmental (1.51%-6.25%)”.

In addition, the ordering of the metaphors created by the students regarding the concept of mathematics from the most common to the least heaped up theme is as follows: “being valuable (23.09%), holding the opposites together (19.76%), being embedded in life (17.38%), distressing (12.61%), being relatable (7.38%), immutable and systematic (7.14%), infinite (4.52%), effortful (3.57%), hard to comprehend (3.09%), and developmental (1.42%)”.

Table 5
Frequency of themes by the department

Themes	Colours		Foods		Vehicles		Seasons		Total		Percentage (%)	
	PMT	UM	PMT	UM	PMT	UM	PMT	UM	PMT	UM	PMT	UM
Embedded in life	14	9	20	22	4	2	1	1	39	34	53.42	46.57
Valuable	12	11	11	9	17	9	14	14	54	43	55.67	44.32
Relatable	2	3	6	4	8	5	3	0	19	12	61.29	38.70
Holding the opposites together	8	2	13	8	4	5	25	17	50	32	60.97	39.02
Immutable and systematic	5	3	0	3	7	7	1	4	13	17	43.33	56.66
Infinite	4	9	1	0	1	4	0	1	6	14	30	70
Develop-mental	0	2	0	1	0	2	1	0	1	5	16.66	83.33
Hard to compre-hend	3	3	1	0	3	1	1	1	8	5	61.53	38.46
Effortful	1	0	0	0	6	4	2	2	9	6	60	40
Distressing	8	6	5	1	7	9	9	8	29	24	54.71	45.28

As shown in Table 5, it is clear that the answers of the PMT students (53.42%) fit under the theme of being “embedded in life” more than those of the UM students (46.57%), and the metaphor of food (57.53%) was used more than other metaphors. The general features of the metaphors that make up this theme are as follows:

(1) Mathematics is the building block of life and science (white, yellow, black, rainbow, water, meat, latte, tomatoes, protein, salt, food, bread, public transport, vehicles, buses)

(2) Mathematics is a comprehensive course which exists in every field (white, black, rainbow, blue, colour of life, carbohydrates, fatty foods, Noah’s pudding, wheat, bread, protein, buses, cars, and four seasons).

> “*Mathematics is like a tomato because there are no meals without tomatoes, and no life without mathematics* (PMT1K26).”
> “*Mathematics is like Noah’s pudding because it is comprehensive, and it includes and deals with everything* (UM1E7).”

The answers of the PMT students (55.67%) fit under the theme of being “valuable” more than those of the UM students (44.32%), and the metaphor of season (28.86%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is a useful and favourite subject (white, sea, blue, orange, rainbow, pink, black, purple, yellow, green, lilac, sweet, fast food, doner kebab, cauliflower, walnut, vegetables, fruit and vegetables, milk, chocolate, spinach, leaf vegetables, meat dishes, car, plane, ambulance, the Taurus Mountains, public transport, motorcycle, bumper car, cable car, bus, spring, autumn, summer, spring and autumn, winter)

(2) Mathematics is the act of approaching from different angles (rainbow and cars).

(3) Mathematics is an addictive subject (blue, sunflower seeds, tea, kebab, spinach, meat, cars, winter, and four seasons).

"*Mathematics is like spring because, like spring, every new piece of knowledge in mathematics makes people bloom* (UM2E2)."
"*Mathematics is like a car. Everyone has their own unique style of solving a math problem, just like everyone having a different car* (PMT1K6)."
"*Mathematics is like the winter. Just like we put on some other clothes to warm us up when we get cold in the winter, as we learn in mathematics, we want to learn more* (UM1E10)."

The answers of the PMT students (61.29%) fit under the theme of being "relatable" more than those of the UM students (38.70%), and the metaphor of vehicles (41.93%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is composed of many topics (white, Turkish bulgur salad, salad, pomegranates, potatoes, grapes, soup, train, watercraft, subway, bus)
(2) Mathematics is a subject related to other sciences (white, tahini, tomato, milk, bread, bus, minibus, and spring).

"*Mathematics is like a train. Every topic you learn and can learn is chained like wagons* (PMT1K4)."
"*Mathematics is like a bus. There are different people on the bus and likewise, there are different topics in math* (PMT2E1)."
"*Mathematics is like a minibus. Mathematics also includes every school subject, just like a minibus, which accommodates people from all walks of life* (UM2K3)."

The answers of the PMT students (60.97%) fit under the theme of "holding the opposites together" more than those of the UM students (39.02%), and the metaphor of seasons (51.21%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is a lesson that connects positive and negative emotions (grey, a chessboard, the colour of chilli isot pepper flakes, water, oranges, peppers, okras, chocolate, pickles, green peppers, plums, honey, cola, broccoli, peaches, eggplant, cactus fruit, Doritos, bread, sea water, truck, train, bicycle, motor, motorcycle, jet, semi-trailer truck, autumn, spring, summer, winter, and four seasons)

"*Mathematics is like the spring. Although there are sunny days in the spring, it can rain at any time. In mathematics, likewise, you may encounter difficulties when you least expect them* (UM1K4)."
"*Mathematics is like sea water. Sea water is neither drinkable nor can be abandoned, just like mathematics* (UM2E2)."

The answers of the UM students (56.66%) fit under the theme of "immutable and systematic" more than those of the PMT students (43.33%), and the metaphor of a vehicle (46.66%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics consists of certainty and proof (blue, the colour of water, white, transparent, water, airplane, Volvo).
(2) Mathematics is a course with an algorithm (bicycles, cars, horse-drawn carriages, trains, motorcycles, and all vehicles).

> "*Mathematics is like a Volvo. It is solid and proven. No one can beat mathematics with their theories* (UM2K7)."
> "*Mathematics is like a horse-drawn carriage. If you don't lead the horse, the carriage won't go. Therefore, the horse must be taught how to ride on the road. No progress can be made without learning, just like mathematics* (UM1K1)."

The answers of the UM students (70%) fit under the theme of being "infinite" more than those of the PMT students (30%), and the metaphor of colours (65%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is an unlimited collection of knowledge (white, black, blue, yellow, sea, broccoli, spacecraft, spaceship, ship, and winter).

> "*Mathematics is like the colour black because it is always interesting, like the endless space* (UM2E4)."
> "*Mathematics is like a spaceship because like information in mathematics, the spaceship is located in a vast space* (UM1K15)."

The answers of the UM students (83.33%) fit under the theme of being "developmental" more than those of the PMT students (16.66%), and the metaphor of colours and vehicles (33.33%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is open to development and new ideas (white, airplane, bus, and spring)

> "*Mathematics is like a bus. There are those who get on and off the bus, and likewise, in mathematics, each newcomer continues the task where the previous one has left off* (UM2E3)."
> "*Mathematics is like the spring. Nature is renewed in spring. I likened it to this because mathematics is also renewed* (PMT2E1)."

The answers of the PMT students (61.53%) fit under the theme of being "hard to comprehend" more than those of the UM students (38.46%), and the metaphor of colours (46.15%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is a deeply structured course (black, blue, sky, pomegranate, submarine, airplane, spaceship, train, winter, and summer).

> "*Mathematics is like the colour black, which everyone uses a lot but does not know where it actually comes from* (UM1K19)."
> "*Mathematics is like an airplane. No one knows what it is, but everyone is trying to do it* (UM1K17)."

The answers of the PMT students (60%) fit under the theme of being "effortful" more than those of the UM students (40%), and the metaphor of vehicles (66.66%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1) Mathematics is a subject that requires effort and patience (grey, bicycle, bus, car, horse-drawn carriage, winter, spring, and autumn).

> "*We try hard to learn mathematics, just like we do with a bicycle. It is learned both with difficulty and gradually* (PMT1K19)."
> "*Mathematics is like the colour grey because it is neither white nor black, and it takes effort to understand it* (PMT1K3)."

The answers of the PMT students (54.71%) fit under the theme of being "distressing" more than those of the UM students (45.28%), and the metaphor of seasons (32.07%) was used more than other metaphors. The general characteristics of the metaphors that make up this theme are as follows:

(1)Mathematics cannot be achieved by everyone (red, purple, black, cashews, broccoli, spinach, wheelbarrow, car, Ferrari, BMW, Tesla, ship, winter, spring, and summer).

(2)Mathematics is a difficult, disliked and boring subject (purple, white, yellow, black, meat, stuffed peppers, strawberries, airplane, bike, bus, semi-trailer truck, motorcycle, train, pickup truck, winter, autumn, summer, and spring).

> "*Mathematics is like the winter. Snow scenery is beautiful in winter, but most people don't like it* (PMT1K22)."
> "*Mathematics is like cashews. Not everyone can eat cashews, and not everyone can do math* (PMT1E8)."
> "*Mathematics is like the autumn because I have trouble understanding and I feel like trees dropping leaves in autumn* (UM2E1)."

Discussion, Conclusion and Recommendations

Based on the aim of comparing the perceptions of the PMT students and UM students with similar mathematical backgrounds, towards the concept of mathematics, this study revealed some notable results. First, many metaphors are required for a correct and holistic understanding of the concept of mathematics. As an example, although mathematics was limited to the metaphors of "colours", "foods", "vehicles", and "seasons" in this study, it was represented by a total of 103 sub-metaphors (white, water, airplane, spring, etc…). Similarly, for the concept of mathematics, the relevant literature shows that there are 115 metaphors by Güler et al. (2011), 80 metaphors by Çalışıcı and Sümen (2019), and 244 by Yaman and Yaman (2020). As Yob (2003) stated, it is necessary to use more than one metaphor to represent a phenomenon. In this respect, it can be argued that using many metaphors is necessary in order to explain the concept of mathematics in a holistic way.

Secondly, four specific themes (being "valuable", "embedded in life", "distressing, and "holding the opposites together") appeared to be the most common metaphors created by students regarding the concept of mathematics. In addition to this, there are six more themes ("relatable", "immutable and systematic", "infinite", "effortful", "hard to comprehend", and "developmental") which were much less addressed, considering the number of students. However, these six themes are also important, as are the four themes which were largely addressed. For example, the themes "relatable", "effortful", and "developmental" represent that mathematics is associated with "interdisciplinary education" and "self-efficacy", and that "mathematics is not an isolated science". In addition, it can be argued that the themes of "holding the opposites together" and being "embedded in life" represent "daily life", and the theme of being "distressing" represents negative attitude towards mathematics. The relevant literature review has revealed some studies similar to the themes created in this study. As an exemplification, for the theme of being "embedded in life", some other themes found in the literature can be considered relevant and listed as follows: "mathematics in life" (Güveli et al., 2011), "real/common situations" (Uygun et al., 2016), "an activity intertwined with life"

(Turhan Türkkan & Yeşilpınar Uyar, 2016), “necessity” (Tarım et al., 2017), “an area needed in daily life” (Çalışıcı & Sümen, 2019), “mathematics as a necessary tool for life” (Yaman & Yaman, 2020), and “mathematics in everything/everywhere” (Katrancı & Kıral, 2021). For the themes of “holding the opposites together”, the following themes can be assumed to be relevant: “opposite concepts/positive-negative concepts” (Uygun et al., 2016), being “an activity that changes depending on the situation” (Turhan Türkkan & Yeşilpınar Uyar, 2016), “mathematics as a difficult but learnable lesson” (Yaman & Yaman, 2020), and something that “depends on the situation” (Katrancı & Kıral, 2021). Similarly, the theme of being “relatable”, where there is not much clustering seemed to be associated with the following themes such as: “mathematics consisting of many subjects/mathematics as an assistant of other sciences” (Güveli et al., 2011), “basis of other sciences” (Çalışıcı & Sümen, 2019), and “mathematics as a subject that includes many subjects / mathematics as a subject related to many subjects” (Yaman & Yaman, 2020). Moreover, the theme of being “infinite was found to be directly associated with the themes of being “infinite” (Uygun et al., 2016; Katrancı & Kıral, 2021), as well as being “an area that contains many unknowns” (Çalışıcı & Sümen, 2019). Nevertheless, the theme of “effortful”, in which there was not much clustering in this study, was addressed in many studies in the form of metaphors such as mathematics which “requires work” (Schinck et al., 2008), “mathematics as a subject requiring hard work” (Güveli et al., 2011), mathematics which “requires effort/skills” (Sezgin Memnun, 2015; Uygun et al., 2016), “a cognitive and affective effortful activity” (Turhan Türkkan & Yeşilpınar Uyar, 2016), “effort” (Tarım et al., 2017), “a field that requires effort” (Çalışıcı & Sümen, 2019), and an “effortful course” (Yaman & Yaman, 2020).

Third, it was clear that the themes differed in terms of the students’ level of class as well as their department of study. For example, the analysis of the themes according to the students’ level of class indicated that the 1st class students studying in either departments turned out to define mathematics as “holding the opposites together”, “effortful”, and “distressing” outnumbered the 2nd class students, while they were less likely to define it something which is “embedded in life”, “valuable”, “infinite”, and “developmental”. Based on these results, it can be suggested that the hardships (subjects and questions beyond a student’s capacity to comprehend, adaptation to university, or attitude of academics, etc.) experienced by the students as they moved from secondary education to higher education may be the reason why 1st class students believed that mathematics is an effortful course, when compared to what 2nd class students believed (Wintre & Yaffe, 2000). Due to these difficulties, it can also be suggested that students describe mathematics as a lesson that cannot be achieved by everyone and is disliked. In a similar manner, Akhan and Karamik (2019) tried to determine the changes in the perceptions of the first year students of the faculty of education regarding their adaptation to the university. As a result of that study, the students’ tendency for the themes that contain negative attitude, anxiety and prejudice towards the concept of university supports the result of this study. However, there are also studies that reported some negative perceptions towards mathematics as a result of the increase in education level (Uygun et al., 2016; Koçak & Bilecik, 2019). In addition, when compared to the 1st class students, the reason why the 2nd class students considered mathematics as valuable and associated it with daily life with the idea that mathematics continues to develop in the unknown, could be that students learn by doing and experiencing as they adapt to the learning process (Yurtbakan et al., 2016), as well as by listening to the lessons well (Dede & Dursun, 2004), thereby developing their thinking skills (Dane et al., 2009).

As a result of examining the themes according to the students’ department of study, the PMT students who were taking courses on how mathematics should be taught turned out to be more likely to regard mathematics as something which is “embedded in life”, “valuable”, “relatable”, “holding the opposites together”, and “hard to comprehend”, “effortful”, and “distressing”, when compared to the UM students who study advanced mathematics. Similarly, it was also observed that the UM students were more likely to perceive mathematics as "immutable and systematic", "infinite", and "developmental", when compared to the PMT students. The reason for such a result could be the fact that the PMT students' curricula contain less abstract expressions than that of the UM students, give students active roles, provide students with an environment for learning-by-doing, and attach less importance to theoretical courses, and also that the purpose of this department is to train mathematics teachers rather than mathematicians. In this connection, Özdemir (2018) compared the curricula of the Pre-service Mathematics Teachers and the Undergraduate Mathematics within the scope of some variables, and reported results in conformity with those of this study.

To conclude, metaphors can be used as a factor that can contribute positively to questioning, revealing, understanding and improving the perceptions of individuals regarding the concept of mathematics. In this sense, future studies may identify some other different factors underlying individuals' perceptions of mathematics by using different metaphors (e.g., curriculum, academicians, etc.). It is also known that another variable affecting the perceptions of individuals towards mathematics is family attitudes (Lin et al., 2019; Thippana et al., 2020). In this respect, the relationship between individuals' perceptions of mathematics and their families' attitudes towards mathematics could be explored so that the influence of such a relationship could be investigated. The participants of this study were 1st and 2nd class students in two different departments with common mathematical roots. It can be suggested that future researchers conduct similar studies by including students from different departments (Science Education, Engineering Department…) and the results should be compared depending on the level of class and department of study. Also, in order to ensure the validity of this and many other similar studies, longitudinal studies may be conducted by considering the level of class. Thus, it is believed that the changes in the perceptions of individuals towards mathematics can be evaluated in a sound manner.

References

Akhan, N. E., & Karamik, G. A. (2019). Ensuring Adaptation of First-Year Students at the Faculty of Education to University through Creative Drama. *Journal of Education Theory and Practical Research*, *5*(2), 141-152. https://dergipark.org.tr/en/pub/ekuad/issue/47044/591323

Altun, M. (2001). *Mathematics teaching for faculty of education and primary school teachers*. Bursa: Erkam Printing press.

Altun, M. (2008). *Teaching Mathematics in High Schools*, First Edition, Bursa: Aktüel Publications.

Başıbüyük, K. (2018). *The effect of using the history of mathematics in teaching algebra and numbers on success and attitude and in-class reflections* (Doctoral, Atatürk University, Institute of Education Sciences). Accessed from the thesis center database of the Council of Higher Education (503487).

Baykul, Y. (1999). *Effective Teaching and Learning in Primary Education Teacher's Handbook Module 6 Teaching Mathematics in Primary Education*. Ankara: National Education Printing House.

Ben-Peretz, M., Mendelson, N., & Kron, F. W. (2003). How teachers in different educational context view their roles. *Teaching and Teacher Education, 19*, 277-290. https://doi.org/10.1016/S0742-051X(02)00100-2.

Çalışıcı, H., & Sümen, Ö. Ö. (2019). Pre-service Mathematics Teachers' Perceptions about Mathematics Concept: A Metaphor Study. *International Journal of Educational Studies in Mathematics,* *6*(3), 108-123. https://dergipark.org.tr/en/pub/ijesim/issue/49111/620251

Carlson, T. B. (2001). Using Metaphors to Enhance Reflectiveness Among Preservice Teachers. *Journal of Physical Education, Recreation & Dance. 72, 1; ProQuest Education Journals*,49-53. https://doi.org/10.1080/07303084.2001.10605820

Cassel, D., & Vincent, D. (2011). Metaphors reveal preservice elementary teachers' views of mathematics and science teaching. *School Science and Mathematics, 111*(7), 319-324. https://doi.org/10.1111/j.1949-8594.2011.00094.x

Creswell, J.W. (1998) *Qualitative Inquiry and Research Design: Choosing among Five Traditions*. Thousand Oaks, CA: Sage.

Creswell, J.W. (2013). *Qualitative Inquiry & Research Design: Choosing among Five Approaches*. Los Angeles, CA: Sage.

Dane, A., Kudu, M., & Balkı, N. (2009). The Factors Negatıvely Effectıng Hıgh School Students' Mathematıcal Success Accordıng to Theır Perceptıons. *Erzincan University Journal of Science and Technology,* 2(1), 17-35. https://dergipark.org.tr/en/pub/erzifbed/issue/6018/8062

Danesi, M. A. (2007). Conceptual Metaphor Framework for The Teaching Of Mathematics. *Studies in Philosophy and Education 26*, 225-236. https://doi.org/10.1007/s11217-007-9035-5

Dede, Y., & Argün, Z. (2004). Identification of Students' Intrinsic and Extrinsic Motivation Towards Mathematics. Educatıon and Scıence, *29*(134), 49-54.

Dede, Y., & Dursun, Ş. (2004). The Factors Affecting Students Success in Mathematics Mathematics Teachers Perspectives. *Journal of Gazi Education Faculty, 24*(2), 217-233. https://dergipark.org.tr/en/pub/gefad/issue/6759/90924

Font, V., Bolite, J., & Acevedo, J. (2010). Metaphors in mathematics classrooms: Analyzing the dynamic process of teaching and learning of graph functions. *Educational Studies in Mathematics, 75*(2), 131-152. https://doi.org/10.1007/s10649-010-9247-4

Göker, L. (1997). *History of Mathematics and the Place of Turkish-Islamic Mathematicians*. Ministry of Education.

Güler, G., Akgün, L., & Öçal, M. F. (2011). Pre-service mathematics teachers' metaphors about mathematics teacher concept. *Procedia - Social and Behavioral Sciences, 15*, 327-330. https://doi.org/10.1016/j.sbspro.2011.03.095

Güveli, E., İpek, A. S., Atasoy, E., & Güveli, H. (2011). Candidate Class Teachers' Metaphorical Perceptions Towards Mathematics. *Turkish Journal of Computer and Mathematics Education*, *2*(2), 140-159.

Heidegger M. (1867). *Being and time*. Blackwell: Oxford UK and Cambridge USA.

Katrancı, Y., & Kıral, B. (2021). The Perceptions of Pre-Service Middle School Mathematics Teachers Regarding Mathematics and Mathematics Teacher: A Metaphorical Approach. *Asya Studies*, *5*(18), 21-41. https://doi.org/10.31455/asya.940207

Koçak, D., & Bilecik, T. (2019). Comparison and Determination of Metaphors of Mathematics Education at Different Level of Education. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, *13*(2), 909-940. https://doi.org/10.17522/balikesirnef.544055

Kuzu, O., Kuzu, Y., & Sıvacı, S. Y. (2018). Preservice Teachers' Attitudes and Metaphor Perceptions towards Mathematics. *Cukurova University Faculty of Education Journal, 47*(2), 897-931. https://doi.org/10.14812/cuefd.383527

Lakoff, G., & Johnson, M. (2005). *Metaphors: Life Meaning and Language* (Translator G.Y. Demir). İstanbul: Paradigma

Lakoff, G., & Nuñez, R. (2000). *Where mathematics comes from: How the embodied mind creates mathematics*. Basic Books

Latterell, C. M., & Wilson, J. L. (2016). Math is like a lion hunting a sleeping gzelle: Preservice elementary teachers' metaphors of mathematics. E*uropean Journal of Science and Mathematics Education*, *4*(3), 283-292. https://doi.org/10.30935/scimath/9470

Laverty, S. M. (2003). Hermeneutic phenomenology and phenomenology: A comparison of historical and methodological considerations. *International journal of qualitative methods*, *2*(3), 21-35. https://doi.org/10.1177/160940690300200303

Lin, Y. C., Washington-Nortey, P. M., Hill, O. W., & Serpell, Z. N. (2019). Family functioning and not family structure predicts adolescents' reasoning and math skills. *Journal of Child and Family Studies*, *28*(10), 2700-2707. https://doi.org/10.1007/s10826-019-01450-4

Mahlios, M., & Maxson, M. (1998). Metaphors as Structures for Elemantary and Secondary Preservice Teachers" Thinking. *International Journal of Educational Research*, 29, 227- 240. https://doi.org/10.1016/S0883-0355(98)00027-5

Markovits, Z., & Forgasz, H. (2017). "Mathematics is like a lion": Elementary students' beliefs about mathematics. *Educational studies in mathematics*, *96*(1), 49-64. https://doi.org/10.1007/s10649-017-9759-2

Merriam, S. B. (2018). *Qualitative Research: A Guide to Design and Implementation* (Translator S. Turan). Ankara: Nobel Publishing (Original release date, 2009).

Miles, M.B., & Huberman, A.M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage.

Morgan G. (1998). *Metaphor in management and organizations* (Translator, G. Bulut). İstanbul: BZD Publishing.

Nasibov, F., & Kaçar, A. (2005). On the mathematics and mathematics education. *Gazi University Kastamonu Journal of Education*, *13*(2), 339-346.

Neubauer, B. E., Witkop, C. T., & Varpio, L. (2019). How phenomenology can help us learn from the experiences of others. *Perspectives on medical education*, *8*(2), 90-97. https://doi.org/10.1007/s40037-019-0509-2

Noyes, A. (2004). (Re) Producing Mathematics Teachers: A sociological perspective. *Teaching Education*, *15*(3), 243-256. https://doi.org/10.1080/1047621042000257180

Olsen, J., Lew, K., & Weber, K. (2020). Metaphors for learning and doing mathematics in advanced mathematics lectures. *Educational Studies in Mathematics*, *105*(1), 1-17. https://doi.org/10.1007/s10649-020-09968-x

Özdemir, B. (2018). *Comparıson of Undergraduate Programs of Mathematıcs Educatıon and Mathematıcs Departments and Students' Vıew in The Framework of Competencıes* (Master Thesis, Hacettepe University, Institute of Education Sciences). http://www.openaccess.hacettepe.edu.tr:8080/xmlui/handle/11655/5381

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Reeder, S., Utley, J., & Cassel, D. (2009). Using metaphors as a tool for examining preservice elementary teachers' beliefs about mathematics teaching and learning. *School science and mathematics*, *109*(5), 290-297. https://doi.org/10.1111/j.1949-8594.2009.tb18093.x

Saban, A. (2003). A Turkish Profile of Prospective elementary School Teachers and Their Views of Teaching. *Teaching and Teacher Education*, 19, 829-846. https://doi.org/10.1016/j.tate.2003.03.004

Saban, A. (2004). Entry Level Prospectıve Classroom Teachers' Metaphors about The Concept of "Teacher". *The Journal of Turkish Educational Sciences*, *2*(2), 131-155. https://dergipark.org.tr/en/pub/tebd/issue/26128/275216

Schinck, A. G., Neale Jr, H. W., Pugalee, D. K., & Cifarelli, V. V. (2008). Using metaphors to unpack student beliefs about mathematics. *School science and mathematics*, *108*(7), 326-333. https://doi.org/10.1111/j.1949-8594.2008.tb17845.x

Sezgin Memnun, D. (2015). Secondary School Students' Metaphors about Mathematical Problem and Change of Metaphors according to Grade Levels. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, *9*(1), 351-374. https://doi.org/10.17522/nefefmed.30643

Sinclair, N., & Tabaghi, S. G. (2010). Drawing space: Mathematicians' kinetic conceptions of eigenvectors. *Educational Studies in Mathematics*, *74*(3), 223-240. https://doi.org/10.1007/s10649-010-9235-8

Smith, J.L., Karcher, S. & Whitacre, I. (2023). Is i a Number? An Examination of Advanced Undergraduate Students' Definitions of Number. *International Journal of Research in Undergraduate Mathematics Education*. https://doi.org/10.1007/s40753-022-00210-y

Soto-Johnson, H., Hancock, B., & Oehrtman, M. (2016). The interplay between mathematicians' conceptual and ideational mathematics about continuity of complex-valued functions. *International Journal of Research in Undergraduate Mathematics Education, 2*(3), 362-389. https://doi.org/10.1007/s40753-016-0035-0

Soysal, D., & Afacan, Ö. (2012). Metaphors used by primary school students to describe science and technology lesson and science and technology teacher. *Journal of Mustafa Kemal University Institute of Social Sciences*, *9*(19), 287-306.

Strauss, A. L., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage.

Tarım, K., Özsezer, M. S. B., & Canbazoğlu, H. B. (2017). Pre-Service Classroom Teachers; Perceptions of Related with Mathematics and Teaching Mathematics. *Journal of Ahi Evran University Kırşehir Education Faculty, 18*(3), 1032-1052.

Teherani, A., Martimianakis, T., Stenfors-Hayes, T., Wadhwa, A., & Varpio, L. (2015). Choosing a qualitative research approach. *J Grad Med Educ, 7,* 669-70. http://dx.doi.org/10.4300/JGME-D-15-00414.1

Thippana, J., Elliott, L., Gehman, S., Libertus, K., & Libertus, M. E. (2020). Parents' use of number talk with young children: Comparing methods, family factors, activity contexts, and relations to math skills. *Early Childhood Research Quarterly*, *53*, 249-259. https://doi.org/10.1016/j.ecresq.2020.05.002

Toluk, Z. (2003). Third international math and science survey (TIMSS): What is Mathematics. *Elementary Education Online, 2*(1), 36-41.

Turhan Türkkan, B., & Yeşilpınar Uyar, M. (2016). The Metaphors of Secondary School Students Towards the Concept of "Mathematical Problem". *Cukurova University Faculty of Education Journal*, *45*(1), 99-130.

Turkish Language Association (TLA). (2022). *Large Turkish Dictionary*. Turkish Language Association.

Uçar, T. Z., Pişkin, M., Akkaş, N. E., & Taşçı, D. (2010). Elementary Students' Beliefs about Mathematics, Mathematics' Teachers and Mathematicians. *Education and Science, 35*(135), 131-144.

Uygun, T., Gökkurt, B., & Usta, N. (2016). Analysis of the Perceptions of the University Students about Mathematics Problem through Metaphor. *Bartın University Journal of Faculty of Education*, *5*(2), 536-556. https://doi.org/10.14686/buefad.v5i2.5000187677

Wintre, M.G., & Yaffe, M. (2000). First-year students' adjustment to university life as a function of relationships with parents. *Journal of Adolescent Research, 15*(9), 9-37. https://doi.org/10.1177/0743558400151002

Yaman, F., & Yaman, B. (2020). Metaphorıc Perceptıons of Secondary School Students on Mathematıc Concept. *Eurasian Journal of Researches in Social and Economics*, *7*(6), 250-265. https://dergipark.org.tr/en/pub/asead/issue/55211/737640

Yetim Karaca, S., & Ada, S. (2018). Determining Students' Perceptions Regarding The Mathematics Course and Mathematics Teachers Through Metaphors. *Kastamonu Education Journal*, *26*(3), 789-800. https://doi.org/10.24106/kefdergi.413327

Yob, I. M. (2003). Thinking Constructively with Metaphors. *Studies in Philosophy and Education*, 22, 127-138. https://doi.org/10.1023/A:1022289113443

Yurtbakan, E., Iskenderoglu, T. A., & Sesli, E. (2016). The views of the classroom teachers on enchancing the students' success of mathematics. *Ondokuz Mayis University Journal of Faculty of Education*, *35*(2), 101-119. https://doi.org/10.7822/omuefd.35.2.7

Zandieh, M., Ellis, J., & Rasmussen, C. (2017). A characterization of a unified notion of mathematical function: The case of high school function and linear transformation. *Educational Studies in Mathematics*, *95*(1), 21- 38. https://doi.org/10.1007/s10649-016-9737-0

Appendix I

Department:
Class:
Gender:

Dear participants,

This study has been prepared to determine your "perspective towards mathematics". Since the answers you give are of a nature that will contribute to mathematics education, it is strongly requested that you do not leave the questions empty. Your answers will only be used for statistical analysis and will not be shared with anyone. You can share your questions and opinions about the research process with the contact address below. This work will take about 15 minutes. Thank you for your participation.

Researcher: …
Institution: …
Contact: …

1. Complete the following sentence.
I came to this department "………..". a) willingly b) unwillingly
2. "Mathematics is like/similar to the color of "……..".'' Fill in the dotted place in the sentence.
3. What is your reason for writing this statement in the dotted place?
4. "Mathematics is like/similar to "……..'' food.'' Fill in the dotted place in the sentence.
5. What is your reason for writing this statement in the dotted place?
6. "Mathematics is like/similar to the "……..'' vehicle.'' Fill in the dotted place in the sentence.
7. What is your reason for writing this statement in the dotted place?
8. "Mathematics is like/similar to the "……." season.'' Fill in the dotted place in the sentence.
9. What is your reason for writing this statement in the dotted place?

Appendix II

Some of the participant responses regarding colours, foods, vehicles, and seasons are given below.

Colours:
*"Mathematics is like the colour **white**. White consists of many colours, and mathematics is also associated with many fields."* **(PMT1K4)**
*"Mathematics is like the colour **white**. White is clear, with no contradiction. Mathematics is free from flaws and has a logical explanation for everything."* **(UM1E3)**
*"Mathematics is like the colour **black**. You always feel like you are going into the dark and you can run into all sorts of problems."* **(PMT1K27)**
*"Mathematics is like the colour **black**. We do not see any bright days."* **(UM1E7)**
*"Mathematics is like the colour **blue** because blue is the colour of the sky, and mathematics is as deep as the sky."* **(PMT1K22)**
*"Mathematics is like the colour **blue**. It is endless as you go into it, just like the sky."* **(UM2E1)**

Foods:
*"Mathematics is like **water**. Without water, life cannot be sustained, and likewise, without mathematics, most sciences are baseless."* **(PMT1K10)**
*"Mathematics is like **water**. Without water, there would be no life, without mathematics, it would be impossible to get anywhere."* **(UM1K1)**
*"Mathematics is like **pepper**. Pepper is hot, but adds flavour to food, and likewise, mathematics is bitter but adds flavour to life."* **(UM2E4)**
*"Mathematics is like **pepper-** difficult to eat, but healthy."* **(PMT1E5)**
*"Mathematics is like **bread**. It completes the meals. Without mathematics, other subjects would be incomplete."* **(PMT2K8)**
*"Mathematics is like **bread**. ...just as bread does not leave anyone stranded and starving, so is mathematics."* **(PMT2K17)**
*"Math is like **broccoli**. Not everyone likes math."* **(PMT1K1)**
*"Math is like **broccoli**. It is a healthy food but has no taste."* **(UM1E9)**
*"Mathematics is like **sunflower seeds** because it is addictive as we succeed."* **(UM1K20)**
*"Mathematics is like **sunflower seeds**. It is addictive; the more you eat, the more you want to."* **(PMT1E1)**

Vehicles:
*"Mathematics is like an **airplane** because when you succeed, it lifts you to wherever you want."* **(PMT2K6)**
*"Mathematics is like an **airplane**. ... Mathematics is also developing very rapidly."* **(UM1K14)**
*"Mathematics is like a **bicycle**. If you try you will succeed, if you don't you will stay where you are."* **(UM1K21)**
*"Mathematics is like a **bicycle** because it takes effort."* **(PMT1E1)**
*"Mathematics is like a **bus**. Every difficult question needs more time, just like the bus."* **(PMT1K24)**
*"Mathematics is like a **bus**. There are those who get on and off the bus, and likewise, in mathematics, each newcomer continues the task where the previous one has left off."* **(UM2E3)**
*"Mathematics is like a **car/vehicle**. Not everyone can afford a car, not everyone can do math."* **(PMT1K14)**
*"Mathematics is similar to a **car/vehicle**. As cars are the most used vehicles, so is mathematics, which is used a lot in our lives."* **(UM2E1)**
*"Mathematics is like a **train**. Every subject you have learned and can learn is connected in chains like wagons."* **(PMT1K4)**

*“Mathematics is like a **train**. We can see something different in every wagon.”* **(UM1K22)**

Seasons:
*“Mathematics is like the **spring**. It has both heat and cold. It intimidates with its difficulty and fascinates with the ease it brings.”* **(PMT1K10)**
*“Mathematics is like the **spring**. Spring rewards you for what you sow, so it does mathematics. When you work, it rewards you”* **(UM1K1)**
*“Mathematics is like the **autumn**. It is a mixed season. Suddenly, it starts to rain, and then the sun comes out. Mathematics is like the sun when we can do it, and like the rain when we can’t.”* **(PMT1K8)**
*“Mathematics is like the **autumn**. You get over a bad day, and you say ‘Okay, it’s gone’, but the next day could be even worse. The more you learn, the harder it gets.”* **(UM1E9)**
*“Mathematics is like the **winter**. Snow scenery is beautiful in winter, but most people don’t like it.”* **(PMT1K22)**
*“Mathematics is like the **winter**. It is very rough and difficult.”* **(UM1E6)**
*“Mathematics is like the **summer**. When you look at mathematics from the outside, it looks very cold. But if you like math, it will feel warm. It’s just like the summer.”* **(UM2K6)**
*“Mathematics is like the **summer**. It burns our brains, like the summer sun.”* **(PMT2K13)**