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Preservice Mathematics Teachers' Metaphorical Perceptions towards Proof and Proving

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Abstract

Since mathematical proof and proving are in the center of mathematics; preservice mathematics teachers' perceptions against these concepts have a great importance. Therefore, the study aimed to determine preservice mathematics teachers' perceptions towards proof and proving through metaphors. The participants consisted of 192 preservice mathematics teachers in a public university in Aegean Region. As a data collection tool, to reveal preservice mathematics teachers' metaphorical perceptions towards the proof and proving, the form that includes the blanks in the sentences "Mathematical proof is like… Because…" and "Mathematical proving is like… Because…" Data was analyzed using content analysis method. Sixteen themes about the concept of proof and twenty themes about the concept of proving were composed. After taking a specialist opinion, Miles&Huberman's reliability co-efficient was calculated .92. According to the research results; preservice mathematics teachers had positive perceptions for mathematical proof; but in the matter of proving, they had negative perceptions.As a recommendation, it should be conducted to present why preservice mathematics teachers' perceptions about proof and proving are negative by using depth interviews.

Keywords: mathematical proof, proving, metaphor, preservice teachers' perceptions

1. Introduction

"Any human research that isn't able to pass mathematical proof, cannot be entitled as a principal science." with this statement, Leonardo da Vinci drew attention to the importance of mathematical proof. Mathematic is a scientific proving discipline which composes; axioms, definitions, theorems, proofs and hypothesis and with this peculiarity, it differs from other disciplines (Heinze & Reiss, 2003). For this reason, mathematical proof is in the centre of mathematics (Ball, Hoyles, Jahnke, & Movshovitz-Hadar, 2002; Ko, 2010; Mingus & Grassl, 1999; Tall, 1998).

Mathematical proof is used for; proving a result, inform others and convince them, finding a result and place this result in a deductive system (Almeida, 2003). And proving is the path that followed in the process of the generalisations being produced (Altun, 2011). In the process of proving, firstly, the accuracy of the assertion is examined (accuracy phase); secondly, it is explained why the assertion is accurate (explanation phase); and in the third phase, it's being abstracted by controlling the generalisation conditions (Baki, 2008).

While proving, since it is shown why the situation is true as well as its correctness or incorrectness (Hanna, 2000); proving has an effect on the identity mapping of mathematics concepts and terms (Herbst, 2002). From this point of view, since it gives meaning to the process, proving plays a huge role in the mathematic education. Even if in our country the renewed secondary school education (from 5th grades to 8th grades) does not have any direct gain about proof and proving, the general purpose of curriculum contains to foresee the basic skills such as problem solving and mathematical process abilities (communication, reasoning, associate). Accordingly, instead of proving, it's being dwelled on to gain new information by using mathematics' own tools (symbols, descriptions, connections, etc.) which be obtained from problem solving skill and reasoning and its thinking technique as induction, deduction, comparison, generalisation (The Ministry of National Education [MoNE], 2013). Therefore, students start experiences about verification, explanation, defending and proving in elementary schools (Martin & Harel, 1989).

Because the basics of proving were started in elementary school years, the mathematics teachers who are the practitioners of the curriculum have a great responsibility. And in the period when students gain the proof ability, teachers' conceptions towards proof, their experience and their talents should be effective (Almeida, 2003; Moralı, Uğurel, Türnüklü, & Yeşildere, 2006). In that case, it is obvious that the preservice mathematics teachers' conceptions, opinions and abilities towards proof and proving are important.

In the literature, there are many studies that present preservice teachers' proof abilities (Cusi & Malara, 2007; Dane, 2008; Sarı, Altun, & Aşkar, 2007; G. Stylianides, A. Stylianides, & Philippou, 2005), perceptions towards proof (Almeida, 2000) and opinions (Aydoğdu-İskenderoğlu & Baki, 2011; Baştürk, 2010; Doruk & Güler, 2014; Jones, 2000; Kayagil, 2012; Knuth, 2002; Köğce, 2013; Miral, 2013; Varghese, 2009). A wide range of these studies indicated that preservice teachers' proof abilities, perceptions and opinions toward proof and proving were problematic. In this research, preservice mathematic teachers' methaphorical perceptions towards proof and proving were examined.

Metaphors are the mental models that provide individuals to see a phenomenon with another phenomenon (Saban, 2008). Metaphors, gives the opportunity a conception; to describe with another conception, characterise it by a different conception's assimilation aspect, seeing it in a different dimension and comment in a different form (Tompkins & Lawley, 2002). In the recent years, by using metaphors on the researches; it is gained wide perspective to the existing problems and by bringing the diagrams out of the individuals mind new series of analysis to the existing situations or problems, is can be brought to life (Öztürk, 2007). Therefore, this study has the difference with using the metaphors. In this context, it's worried about that the study will contribute to the literature dramatically.

2. Method

In the research, because it aimed to determine how preservice mathematics teachers perceive proof and proving, the phenomenologic method was used. The general purpose of the phenomenological method is to understand and describe a specific phenomenon in-depth and reach at the essence of participants' lived experience of the phenomenon (Yüksel & Yıldırım, 2015).

The participants in the study consisted of 192 preservice mathematics teachers studying at a public university in Aegean Region in the 2014-2015 academic year. There were 122 females and 70 males ranging in age from 18 to 22. They had an enough number of courses to have information about proof and proving regarding their taken courses.

As a data collection tool, to reveal preservice mathematics teachers' metaphorical perceptions towards the proof and proving, the form that includes the blanks in the sentences "Mathematical proof is like… Because…" and "Mathematical proving is like… Because…" was used. Beforehand preservice mathematics teachers wrote down the metaphors, explanations about metaphors were made. Preservice teachers were asked to write down a metaphor about mathematical proof and proving to the first blank and to explain the reasons why they wrote this metaphor. They were given 20 minutes to complete the form.

The forms which preservice mathematics teachers handed over were read one by one before the classification. During the reading, 34 forms about the concept of proof and 45 forms about the concept of proving that didn't include a metaphor or a "because…" commentary sentence were excluded from decoding. Chosen forms were re-read by the researcher and the metaphors were analyzed with content analysis method. By examining all the metaphors and the metaphor examples, sixteen themes about the concept of proof and twenty themes about the concept of proving were composed. Then, it was asked to a specialist who has metaphor analysis studies to link up these under the themes about the concepts of proof and proving. After that procedure, Miles & Huberman's reliability co-efficient was calculated .92.

3. Results

It is seen that preservice mathematics teachers produced 158 metaphors about the mathematical proof. Besides, the findings obtained from metaphors that was created by preservice mathematics teachers consists sixteen themes. These themes and frequency rates are included in Table 1.

Table 1. The distribution of the metaphors about the proof which were produced by preservice mathematics teachers in accordance with the themes

Themes	Metaphors	Frequency (f)
The proof is a pathfinder.	Teacher (4), compass (4), adress (1), signboard (2), book (2), guide (2), navigation (1), mother (1), map (1), father (1)	19
The proof is the foundation of mathematics.	spirit (1), base of the building (4), tree root (4), water (5), sleep (1), life (1) ,family (1), essence of being (1)	18
The proof is hard be understood.	Foreign language (4), tangle (3), bead (1), putting n contact lenses (1), climbing a mountain (1), analysis course (1), getting to know a person (1), foggy weather (1), diet (1), toast (1), the dress that its colour was at issue (1), my wardrobe (1), hodgepodge (2)	19
There is multiple proof.	Ocean (2), ball-point pen (2), sky (1), unending book (1), unending road (2), universe (1), eternity (2), pi number (1), stars (1), open buffet (1), rain drop (1), sea (1)	16
The proof is unnecessary.	Insult to the scıentists (1), driveler (2), lumber (3)	6
The proof is a product of effort.	Picture (3), making coffee (1), lining (1), child (1)	6
The proof eases the understanding.	Dictionary (1), sunrise (2), evidence (2), sun (3), glasses (1), light (5)	14
The proof breeds another proof.	Turkish conversation (1), mother (2), producer (1), soil (1)	5
The proof is a product of mentation.	Cross word (6), labyrinth game (8), puzzle (7)	21
The proof is mathematicians addiction.	cigarette (4), medicine (2)	6
The proof is a systematic construction.	sweater (1), football (1), spider nest (2), mechanism (1)	5
Proofs are connected to each other.	Matryoshka doll (1), chain ring (2), ladder step (2), train (1), interwoven doors (1), food chain (1)	8
The proof is useful even if it's hard.	Onion (1), pepper (2), walnut (1)	4
The proof gives joy.	Liking (1) , love (2), strike (1), gift pack (1)	5
The proof is precious.	Wine (1), money (1)	2
The proof is the nightmare of the student.	Curse (2), murder (1), death (1)	4
	TOTAL	158

When Table 1 is examined, it's seen that the themes with the most metaphors are respectively; "The proof is a product of mentation." (f=21), "Proof is a pathfinder." (f=19), "The proof is the foundation of mathematic." (f=18) and "There is multiple proof." (f=16). On the other hand themes with the least metaphors are; "The proof is precious." (f=2), "The proof is useful even if it's hard." (f=4), "The proof is the nightmare of the student." (f=4), "The proof gives joy." (f=5), "The proof breeds another proof." (f=5), "The proof is a systematic construction." (f=5). Metaphor examples that were created by preservice teachers are set out below:

Mathematical proof is like a teacher. Because it lets us to see how and where knowledge and theorems comes from.

Mathematical proof is like a compass. Because it lets us to find our way and see what we are doing.

Mathematical proof is like a labyrinth game. Because you can only find the way out by using the rules of logic.

Mathematical proof is like a puzzle. Because after a serious thinking process it leads us to a tableau.

Mathematical proof is like a tree root. Because there can't be mathematic without proof as a tree can't be a tree without the root.

Mathematical proof is like water. Because it's essential. Without the proofs mathematic cannot make progress.

Mathematical proof is like an ocean. Because it's unending. In a sense, as how an ocean is limitless; in mathematic it is possible to see a great number of proof.

Mathematical proof is like love. Because you do not understand what you feel at the beginning but afterwards as you begin to understand, you see how enjoyable and pleasing it is.

Mathematical proof is like a cigarette. Because a mathematician can't hold on without using proof.

Mathematical proof is like a spider's web. Because it advances systematically. When it's seen from outside it may seem complicated but it has a specific structure order on its own.

Mathematical proof is like murder. Because it slaughters the students. Student perishes when seeing a proof.

Mathematical proof is like money. Because how a money has a value, so does proof in mathematic.

Mathematical proof is like wine. Because as the years go by, as its being used it gets more and more valuable for the mathematicians.

Mathematical proof is like a walnut. Because however it may seem stiff from outside, its inside is beneficial for human health. And proof also may seem hard but it makes easier to understand mathematical expressions.

Mathematical proof is like a mother. Because every proof provides for another proof to be born just like a mother would.

In addition to this, other themes that comes to the forefront are; "The proof is hard to be understood." (f=19), "The proof eases the understanding." (f=14), "Proofs are connected to each other." (f=8). Preservice mathematics teachers' metaphors who are related to them and the rest of the themes are as follows:

Mathematical proof is like a foreign language. Because it's hard to understand. Just as we cannot understand a language that we don't know; the moment we see a proof, we astonish and don't understand.

Mathematical proof is like a tangle. Because it cannot be solved, understood. For once you try to understand, but no matter where you look, what you do it won't be solved.

Mathematical proof is like a dictionary. Because how a dictionary helps us to understand the words that we don't know so does proof, it explains where the rule has come from in mathematic.

Mathematical proof is like a light. Because it eliminates the questions in our head and it emerges our mind into the daylight. When it's given a theorem to us we are like in a dark room. As soon as we see its proof the lights turn on.

Mathematical proof is like insult to the scientists. Because as if we don't trust what they do, their theorem's trueness is being tested.

Mathematical proof is like a painting. Because it's a product of an effort. As the painting is made there is great effort and so is with the proof it's made with great efforts too.

The findings obtained from 147 metaphors about mathematical proving that produced by preservice mathematics teachers consists of twenty themes. These themes and frequency rates are included in Table 2.

Table 2. The distribution of the metaphors about the proving which were produced by preservice mathematics teachers in accordance with the themes

Themes	Metaphors	Frequency (f)
Proving is a diffucult job.	Cooking rice dish (1), get blood out of a stone (3), untangling fuzzy hair (2), look for a needle in a haystack (3),climbing to the top (4), sort out stone out of rice (1),listening to the teacher (1), go on a diet (1),being a predident to an	23

	undeveloped country (1), learning a foreign language (1),split the atom (1),explaining quantitive to a verbal person (1), dead end (3)	
Proving is a demanding work.	Babysitting (1), working (1), buiding a structure (1), being a marathon runner (1)	4
Proving is delightning.	Scorring a oal (1), drinking alcohol (2), eating chocolate (1), listening to music (1), eating ice cream (1)	6
Proving is a endemic job for professional mathematicians.	Being a construction foreman (1), doing a Professional work (3)	4
The ability of proving is a acquired with time.	a baby's toddling (1), learning literacy (1), driving a car (3)	5
Proving is terrifying.	Cancer (1), being stuck in a deserted island (1), watching a horror movie (2), phobia (1), punishment (1)	6
Proving is the foundation of mathematic.	The heart of Mathematic (1), sleeping (1), sun light (1), bread and water (1)	4
Proving is a systematical mathematic activity.	Line up dominos (2), knitting (4), writing a poem (1), playin an enstrument (1), conduct an experiment (1), climb up stairs (3), writing a novel (2)	14
Proving triggers new proofs to arise.	Road making (3), ladder (2), treeplanting (2), pomegranate (1)	8
Proving is unnecessary.	Pissing into the wind (3), a coin (1)	4
Proving helps us to understand easier.	Using smartphone guidebook (2), contact list (1), washing hands (1), telescope sight (1), cause (1), making a statement (2)	8
To prove, you have to memorize.	Memorizing (3)	3
Proving requires attention.	Walking on a foggy day (1), walking in the dark (2)	3
It's a necessity to prove	Going out to buy bread (1), taking a exam (1), force eating (1)	3
Being able to prove is an enigma.	Power outage (1), leaven the lake (1), gambling (1), relativity theory (1)	4
Proving is precious.	Contrivance (6), mother (2), treasure (3)	11
While proving, mental process abilities are used.	Solving a crossword (6), doing a puzlle (7), playing mind game (6), labyrinth game (5)	24
Proving can be done in different ways.	Wear make-up (1), rainbow (1)	2
Proving is allows you to work your mind.	Eating hot pepper (1), exercise (1), mind gym (1)	3
Proving makes the life difficult.	Torture (4), commiting suicide (1), get poisoned (2), smoking cigaret (1)	8
	TOTAL	147

According to Table 2, the themes with the most metaphors whom were made by preservice mathematics teachers are; "While proving, mental process abilities are used." (f=24), "Proving is a diffucult job." (f=23), " Proving is a systematical mathematic activity." (f=14) and "Proving is precious." (f=11). Metaphor examples that were created by preservice teachers are set out below:

Mathematical proving is like solving crossword. Because you need to ponder. While making a proof; you need to *show step-by-step what comes from where and which way you should follow.*

Mathematical proving is like climbing to the top of the mountain. Because reaching to the result is not easy at all.

Mathematical proving is like line up dominos. Because if you made a mistake; the result wouldn't mean anything.

Mathematical proving is like writing a novel. Because it has a certain authoring discipline.

Mathematical proving is like contrivance. Because it's very precious. Every committed proof is a contribution to mathematic.

Mathematical proving is like a treasure. Because it's valuable to the mathematical thinking process. After all the important thing in mathematic is the richness of this process.

And the themes with the least metaphors are; "Proving can be done in different ways." (f=2), "To prove, you have to memorize." (f=2), "Proving is allows you to work your mind." (f=3), "Proving requires attention." (f=3), "It's a necessity to prove." (f=3), "Proving is a demanding work." (f=4), "Proving is a endemic job for professional mathematicians" (f=4), "Proving is the foundation of mathematics." (f=4), "Proving is unnecessary." (f=4), "Being able to prove is an enigma." (f=4), "The ability of proving is an acquired with time." (f=5).

Mathematical proving is like applying make-up. Because it's possible to make it in different ways. There's not only a rule or a way to do it.

Mathematical proving is like exercise. Because it provides your brain to work better.

Mathematical proving is like memorizing a transcript. Because it's a work that can only be done by memorizing.

Mathematical proving is like walking in the dark. Because it requires to be more careful. We need to be more slow and cautious to not fall down when walking in the dark. It's the same when making a proof, to reach to the result you need to be careful.

Mathematical proving is like taking an exam. Because it's not permissive, it's obligatory. We take the exams indispensably to finish the schools. And we make proofs indispensably to pass math classes.

Mathematical proving is like taking care of a baby. Because it's a pretty demanding and hard period.

Mathematical proving is like doing a professional work. Because it's a not a task that everybody can achieve; it's a task that only a true mathematician can do.

Mathematical proving is like the heart of mathematic. Because without making a proof mathematic can't survive.

Mathematical proving is like pissing into the wind. Because there is no need to do it. I think it's a waste of time.

Mathematical proving is like power outage. Because it's a unclear situation. When the electricity cut there's not a certain time when it'll come back; you just wait until it comes. Making a proof is as unclear as this. One day you're able to do one; other day you can't even begin to write something down.

Mathematical proving is like learning how to read and write. Because it takes time. As we can't learn how to read and write right away; we can't make a proof at once too.

In addition to these, other themes that outstands are; "Proving triggers new proofs to arise." (f=8), "Proving helps us to understand easier." (f=8), "Proving makes the life difficult." (f=8), "Proving is delighting." (f=6) and "Proving is terrifying." (f=6).

Mathematical proving is like planting a tree. Because how a tree grows and branches out, so does the proof it branches out and causes to arise a new proof.

Mathematical proving is like torture. Because while making a proof; you feel unhappy and like you're hurting.

Mathematical proving is like smoking cigarette. Because how a person's health worsen; so is when making a proof, it worsens your mental health.

Mathematical proving is like scoring a goal. Because you feel the joy as playing a football match when making a proof.

Mathematical proving is like eating chocolate. Because making a proof is very delighting.

Mathematical proving is like watching a horror movie. Because every moment you feel anxious and afraid.

Mathematical proving is like phobia. Because even the thought of making a proof is enough for you to feel terrified.

4. Discussion, Conclusions and Suggestions

4.1 Preservice Mathematics Teachers' Metaphorical Perceptions towards Proof

When the themes from the metaphors about proof were analyzed; twenty one of preservice mathematics teachers think that the proof is a product of mentation. This thinking is a normalcy. As a matter of fact in mathematics and in the proof which is the foundation of the mathematics, logical reasoning is in the foreground. The likely relevant themes on that matter are; "The proof is a systematic construction." (Produced by five preservice teachers) and "The proof is a product of effort." (Made by six preservice mathematics teachers). As the correctness of the claim are shown with several and sufficient evidence; interested description, axioms and theorems' right and proper usage are befitting. And this shows that preservice mathematics teachers are aware that mathematical proofs are not produced randomly.

Nineteen of preservice mathematics teachers indicate that proof's guiding effect, eighteen of them pointed out that it's the foundation of the mathematics and fourteen of them state that it's an effect on easing the understanding. Still when the metaphors are examined, it's seen that they think that the proof gives joy (f=5), that it's beneficial (f=4) and that it's precious (f=2). Herefrom, it can be said that sixty two of preservice mathematics teachers (approximately 39%) have positive opinions towards mathematical proof. Study results shows parallelism with the studies of Aydoğdu-İskenderoğlu and Baki (2011) and Lee (1999). These studies showed that preservice mathematics teachers have positive opinions towards the proof. However, in the study performed by Almeida (2000), Moralı et al. (2006), and Doruk and Güler (2014), it was determined that preservice teachers don't set out a clear view for proof. The inconstancy of the study results about the mathematical proof may have been derived from the different periods of time and the variation of the practices.

On the other hand the results obtained from the research, nineteen of metaphors about mathematical proof come under theme of "The proof is hard to understand"; six of them come under theme of "The proof is unnecessary" and four of them come under theme of "The proof is the nightmare of the students". Hence it can be said that twenty nine of preservice teachers (approximately %18) have negative opinions towards mathematical proof. In the research of Moralı et al. (2006); it was found that preservice mathematics teachers think that understanding of mathematical proof was hard (% 31.8) and the proof was unnecessary (% 43).

According to the themes which are acquired from the metaphors, preservice teachers think that mathematical proofs are connected to each other (f=8), it's mathematicians' addiction (f=6) and the mathematical proof provides to breed a new proof (f=8). It can be said that these themes are connected to each other. For an exact mathematician, it's not a single way to prove a theorem. Since he has the ambition for mathematics, there's always this question: "How can this be done differently?" in his mind. And this leads him to do it in varied ways. Thus a new proof is born. And that proof may help to create another proof. For this reason, it can be said that it's connected. Also preservice teachers produced metaphors which indicated that there's multiple proofs (f=16). Considering that preservice mathematics teachers encounter with many different proofs in every mathematics lesson in university, it's expected to think like that.

4.2 Preservice Mathematics Teachers' Metaphorical Perceptions towards Proving

When preservice mathematics teachers' perceptions towards proving were analyzed; in parallel with their metaphorical perceptions towards the proof, they produced metaphors revealing that they use mental process skills when proving (f=23). And this shows that preservice mathematics teachers tend to select the appropriate method to prove and use related definition, axioms and theorems. In the study which was used "Questionnaire for Constructing Mathematical Proof" of Aydoğdu-İskenderoğlu and Baki (2011); one of the factors in the scale is mental process. Preservice teachers' general averages in the items which contains mental process indicates that they approach to prove in a positive mental process way. And this was interpreted by the researchers as they often use their mental process. Additionally, preservice mathematics teachers think that proving is; a mathematical activity (f=14), a demanding work (f=4) and that it requires attention (f=3). Zhou and Bao (2009) indicates in the studies which were conducted with 152 preservice mathematics teachers; 86% of them, with regard to what is mathematical proof, reply to use proper rules while proving. And in the study of Cansız-Aktaş and Aktaş (2013), with the mathematics department students, it was seen that participants produced metaphors showing that they perceive proving as a work of patience, effort, care and attention.

In the research, there are metaphors that represents proving as a difficult work (f=23). In addition to this, preservice teachers consider proving as a life aggravation (f=8), terrifying (f=4), unnecessary (f=4), mendatory (f=3) and as a enigmatic process (f=4). Namely, forty eight of preservice mathematics teachers (approximately % 33) have negative perceptions towards proving. And the other studies that were conducted with undergraduates shows that they had difficulties while proving (Almeida, 2000; Cansız-Aktaş & Aktaş, 2013; Dreyfus, 1999;

Harel & Sowder, 1998; G. Stylianides, A. Stylianides, & Philippou, 2007); they thought that proving is unnecessary (Gökkurt & Soylu, 2012; Knuth, 2002) and they didn't trust themselves exactly while proving (Anapa & Şamkar, 2010; Baştürk, 2010; Doruk & Güler, 2014; Doruk, Özdemir, & Kaplan, 2014; Gökkurt & Soylu, 2012; Moralı et al., 2006). This may be because they completely encountered with a formal mathematical proof at university. And this transition may seem harsh and lead them to have negative opinions towards proving. In furtherance of the researcher's this opinion, three preservice teachers have the perception which is to prove you have to memorise. This shows that preservice mathematics teachers haven't interiorised proving. Therefore, it has a great importance to give place to informal proof activities at young ages, to improve proving abilities taking part in primary and high school curriculums with appropriate activities and lecture transition courses about mathematical proof and proving at university.

Paralelly to perceptions towards mathematical proving, preservice mathematics teachers think that proving triggers new proof ways to arise (f=8), proving can be done in different ways (f=2) and proving ability is a acquired characteristic. Along with this, they also think that proving is precious (f=11), eases the understanding (f=8), is the foundation of mathematics (f=4) and it provides the mind to work better (f=3). It can be said that twenty six of preservice teachers (approximately %18) have positive perceptions towards proving. As Furinghetti and Morselli (2009) stated; since the opinions towards proving affect the proving abilities, it will also affect preservice teachers proof making frequency at their classes (Aydoğdu- İskenderoğlu & Baki, 2011).

The results of the study shows that preservice mathematics teachers have positive perceptions towards mathematical proof and negative perceptions towards proving. This case can be interpreted as even they regard mathematical proof significant, because they think they're not qualified to prove or don't trust themselves on this matter, they have negative perceptions towards proving. In furtherance of the researcher views, three preservice teachers think that proving is a specific work for professional mathematicians. Within this concept, it is considered that it's important to give place to activities improving proving abilities and showing that proving allows for conceptual learning; hence, negative perceptions towards proving will eliminate.

4.3 Suggestions

Further research should be carried out:

- to examine whether preservice mathematics teachers' metaphorical perceptions differ to gender, class level, alma mater, etc..
- to present why preservice mathematics teachers' perceptions about proof and proving are negative by using depth interviews.
- to examine what mathematics teachers' and middle or high school students' perceptions towards proof and proving are.

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Note

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