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ELEMENTARY MATHEMATICS TEACHER CANDIDATES' ATTITUDES TOWARDS PROOF AND PROVING

ABSTRACT

In this research, in order to determine the opinions of teacher candidates from elementary mathematics education towards mathematical proof and proving, identification of situation was made. An attitude scale towards mathematical proof and proving was developed through the survey which Moralı et al. (2006) developed from Almeida's study and literature. Validity of construction of the scale was done in three ways: (1) factor analysis, (2) item-total correlation and (3) distinctiveness of items and two factors were determined: "attitude towards proving" and "general aspect to the proof". Cronbach Alpha reliability coefficient of the scale was found as 0.897 and this value demonstrated that the scale was reliable. To analyze the data t-test for independent samples and MANOVA in SPSS 12.0 package program were used. By the t-test for independent samples it was seen that school year and gender were effective on the scores taken from attitude scale of teacher candidates. According to the MANOVA analysis, it was found that the scores of "attitude towards proving" and "general aspects to proof" were effective on school year and gender.

Keywords: Attitude Scale, Mathematical Proof, Mathematics Education, Proving, Teacher candidates

İLKÖĞRETİM MATEMATİK ÖĞRETMEN ADAYLARININ İSPAT VE İSPAT YAPMAYA YÖNELİK TUTUMLARI

ÖZET

Bu çalışmada, ilköğretim matematik eğitimi öğretmen adaylarının ispat ve ispat yapmaya yönelik tutumlarını belirlemek amacıyla tarama modeli kullanılmıştır. Moralı ve diğerlerinin (2006), Almeida'nın çalışmasında geliştirdikleri anket ve literatür doğrultusunda ispat ve ispat yapmaya yönelik bir tutum ölçeği geliştirilmiştir. Ölçeğin yapı geçerliği üç yolla yapılmıştır: (1) faktör analizi, (2) madde-toplam korelasyonu ve (3) maddelerin ayırt edicilik özelliği ve iki faktör tespit edilmiştir: "ispat yapmaya yönelik tutum" ve "ispata yönelik genel bakış". Ölçeğin Cronbach Alpha güvenilirlik katsayısı .897 olarak bulunmuştur ve bu değer ölçeğin güvenilir olduğunu göstermiştir. Verileri analiz etmek amacıyla SPSS 12.0 paket programındaki bağımsız örneklem için t-testi ve Manova kullanılmıştır. t- testi sonucunda sınıf düzeyi ve cinsiyetin öğretmen adaylarının ispat ve ispat yapmaya yönelik tutum puanları üzerinde etkili olduğu görülmüştür. Manova analizine göre "ispat yapmaya yönelik tutum" ve "ispata yönelik genel bakış" puanlarının öğrenim görülen sınıf düzeyine ve cinsiyete göre anlamlı bir farklılık gösterdiği ortaya çıkmıştır.

Anahtar Kelimeler: Tutum ölçeği, Matematiksel İspat, Matematik Eğitimi, İspat Yapma, Öğretmen adayları



1. INTRODUCTION (GİRİŞ)

Science and science-based technology have been affecting or even formalizing gradually and progressively modern life therefore the value of mathematics is an indisputable subject in modern life. Mathematics built by abstract conceptions is based on the base of daily thought that we are accustomed to its regular and current shape. Thought itself isn't strange for us but special symbols expressing our thought are strange for us. Subject of mathematics are; number, point, set, geometric figures, abstract objects as space and making relations between these kinds of objects. Revealing or perceiving a relation is a psychological event that requires rather more creative image, intuition and experience. Proving is an implication as logical argumentation and its' rules and criteria are obvious. Accordingly mathematics can be determined as a science of revealing features peculiar to number, point, set, function, geometric figures and abstract objects as space, determining them and proving them logically.

Proving is a tool in mathematics learning (Knuth, 2002). The development of proving depends on learner's achievements of different ways of logical reasoning. Different argumentations provide building up the knowledge in different aspects. Proof is defined as showing the accuracy of something in Oxford American Dictionary by the year 1980. Proving can also be done in two ways. The former is showing the accuracy of an expression. The latter is explaining why the expression is accurate. Mathematicians are dealing with why the expression is accurate more than whether the expression is accurate. In other words, mathematical proof is a logical explanation of why the expression is accurate (Altıparmak and Öziş, 2005).

Some teachers expressed that according to the students proof is something that makes them believe. Although this interpretation is important, it should be drawn attention to the necessity of the expressions made in classroom and meaningful expressions for students rather than formal conventions (Bell, 1976). In 1989, The National Council of Teachers of Mathematics put forth their Curriculum and Evaluation Standards for School Mathematics consisted of the idea of proving by learners. The longitudinal study had provided mathematics education with important information and research in the quest for a complete understanding of proving by students (Dann, Pantozzi, and Steencken, 1995; Maher and Speiser, 2001; Martino and Maher, 1999).

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

In order to construct the conception of proof; classification, matching, comparing, arranging are the basic conceptions for children at preschool. Therefore, logical reasoning is being expected to occur with giving hypothesis. The learner is in the period of concrete thinking at primary education. For this reason, examples are given for induction principle with undertaking the relationship between part and whole. At the secondary school, constitution of assumption about generalizations and evaluation of assumptions are being expected from the students at the standards of reasoning and proving. At the years of high school, the phase of abstraction is under development. Deduction and induction are constituted in these years (Altıparmak and Öziş, 2005).

By means of increasing the importance of value of proof in mathematics, intellectual process and development of the students from different age groups in proving was a research topic in mathematics education field. However; in primary, secondary education or higher education, at any degree of education where proving take place, proving has occurred as a problem that students are down in the dumps and an unlovable process that students generally fail, believe not to



be successful, fear. This situation was seen through the research findings (Almeida, 2003; De Villiers, 1990; Jones, 2000; Özer and Arıkan, 2002; Raman, 2003). Students' difficulty at learning to prove or understand of the necessity of working on proof, are the main problem in all of the educational studies about instructing proof. "Why do we have to prove this?" is the most frequently asked questions by students. Students can not see the significance of proving beyond fulfilling their teachers' expectations and passing the examinations.

However, as in daily or scientific thoughts, thinking formats that we can say inductive are also in mathematics. These inductive thinking formats involve exploring activities that can be generalized from a special case. Mathematics is not only proving theorem. Each theorem which expresses a specific relation is a generalization. Before all, a mathematician has to reach a generalization that can be proved. Observing a relation or generalizing observed relation, reaching a solution, forming a formula, even catching a clue for a proof is not a deductive thinking; depend on induction form (Güven and Karataş, 2005).

The important matter required paying attention at mathematics education is teaching definitions and theorems. Definitions and theorems have to be taught and learned as in accordance with their originals without changing any point. In the contrary, another definition and another theorem reveal and also they are usually inaccurate. Whereas each theorem had been set to for centuries and thought by hundreds of people, in conclusion an ultimate form was attained (Nasibov and Kaçar, 2005). Fundamental issue is definitions and theorems should be learned and understood as they are (Moralı et al., 2006).

It is stated that students at university degree, have been experiencing varied problems in proving process through various studies and it is seen that teachers have been presenting activities which were lacking of the nature of proof and proving to students. Mathematics candidates' comments towards proof and their evaluations were different from the admitted norm in mathematics community in a research made by Knuth and Elliott and furthermore, it was determined that a lot of teachers in early years of teaching has been limiting expectations about students' skills of proving (Jones, 2000). Proof is a defining feature of mathematics and, in current school reform recommendations in various countries, is considered a fundamental aspect of instructional programs in all grade levels. However, to have success in the goal to make proof central to all students' mathematical experiences, prospective teachers need to have solid understanding of this mathematical concept. If teacher preparation programs are to develop effective instructional practices that will help prospective teachers cultivate proof in their classrooms, it is essential that these practices be informed by research that illuminates prospective teachers' understanding of proof (Altıparmak and Öziş, 2005; Knuth, 2002; Martin and Harel, 1989; Moralı et al., 2006; Movshovitz-Hadar, 1993; Simon and Blume, 1996; Stylianides, Stylianides and Philippou, 2004; Yıldız, 2006).

Many approaches in gender research presume differences between males and females not only in biological, but also in psychological respects. This assumption is supported by a large number of studies in the past decades. With respect to mathematical achievement several investigations over the past decades suggest a trend of decreasing gender differences. First indicated by Senk and Usiskin (1983), Friedman (1989) confirmed in a meta-analysis of 98 studies from the years 1974 to 1987 that "sex difference in favor of males is decreasing over short periods of time" (Friedman, 1989:205). Hyde,



Fennema and Lamon (1990) found similar results in a meta-analysis of over 100 studies. There are few quantitative empirical studies focusing mathematical reasoning and proof which deal exclusively with the aspect of gender differences. Most general studies, on the other hand, provide separate data for female and male students, making comparison possible.

In a follow-up project (Longitudinal Proof Project) following students from grade 8 to 10 these results were confirmed (sample sizes 1500 to 2800). No difference between sexes was found in grades 8 and 10, but in grade 9 the girls scored better for algebraic proofs (Küchemann and Hoyles, 2003). This study also used a test for general mathematical competences in grades 8 and 9. Controlling these basic competences the girls achieve better results in the proof test than the boys. (Heinze, Ufer and Reis, 2007).

Research on students' understanding of mathematical proof has focused on cognitive issues, including the development of students' proof schemes (Harel and Sowder, 1998) and students' misconceptions and difficulties with proof (Balacheff, 1988; Chazan, 1993; Porteous, 1990; Senk, 1985).

Prove has an important place in achieving skills of thinking logically and realizing to prove from the point of view of the basic ways of mathematics, making mathematical estimation, developing mathematical reasons and proofs, evaluating, choosing and using different ways of logical thought and different kinds of proofs. Constitution of proof at learner would improve the skill of mathematical understanding, provide understanding the concepts better and trusting the results and also provide perceiving the things what mathematicians did and the most important is that it would change the structure of mathematical thinking. Therefore, teacher candidates' understanding and compassing of proofs become an important topic. Unfortunately, the number of the study in this field is very little in our country. But these studies are going on abroad (Yıldız, 2006).

In this research, elementary mathematics teacher candidates' attitudes towards mathematical proof and proving were determined. For this reason these questions would be answered whether (1) scores of the attitudes of teacher candidates towards mathematical proof and proving indicate a meaningful difference according to the school year, (2) scores of the attitudes of elementary mathematics teacher candidates towards mathematical proof and proving indicate a meaningful difference according to the gender, (3) factor scores taken from the scale indicate a meaningful difference according to school year, (4) factor scores taken from the scale indicate a meaningful difference according to the gender.

3. METHOD (YÖNTEM)

3.1. Research Model (Araştırma Modeli)

The aim of this study was to determine teacher candidates' attitudes towards mathematical proof and proving. Therefore an attitude scale was developed and given elementary mathematics candidates to complete it. Descriptive research model was used to determine the elementary mathematics teacher candidates' attitudes towards mathematical proof and proving (Karasar, 2006).

3.2. Participants (Katılımcılar)

The universe of research was elementary mathematics teacher candidates who were instructed in second term of 2007-2008 academic year at Faculty of Education of the University of Balıkesir. The sample of the research was 95 elementary mathematics teacher candidates from 1st year and 70 elementary mathematics teacher



candidates from 3rd year. 1st year teacher candidates had already met the concept of proof and proving and 3rd year teacher candidates had used frequently proof at mathematics lessons and had had a lot of information about proof.

3.3. Data Collection Tool (Veri Toplama Aracı)

In order to determine elementary mathematics teacher candidates' attitudes towards mathematical proof and proving and lack of these studies in this subject; an attitude scale which was developed by Moralı et al. before, was developed again and used for this study. The scale developed by Moralı et al. consisted of 20 items in likert-type and 7 factors and answers were classified between completely agree and completely disagree. 20 more items added to this scale through scanning of the literature and then organized by the opinions of experts in the field. Content validity was provided and then validity of construction of the scale was done in three ways: (1) factor analysis, (2) item-total correlation and (3) distinctiveness of items (Çakır, 2004). This scale was applied to 118 elementary mathematics teacher candidates different from the sample of the study. 31 teacher candidates were from 1st year and 87 teacher candidates were from 3rd year. The value of Kaiser-Meyer-Olkin (KMO) is desired to be 0.6 and higher and from the analysis KMO value was found as .813. According to the Barlett test, the value of significant was seen less than .5 so that there was a meaningful relationship between variables, but there was not any meaningful relationship between factors (Büyüköztürk, 2006). And also data were deemed to be appropriate for factor analysis. The items misunderstood by the teacher candidates during the pilot application, were not subjected to factor analyzing. Factor analysis was made upon 35 items with principal competent analysis in SPSS 12.0 package program.

Values of .30 and higher load factors of the items to be taken to scale was based and moreover differences of values would be higher than .1 (Büyüköztürk, 2006:124). After rotating operations, the scale took its' last shape with 21 items and two factors determined: "attitudes towards proving" and "general aspect to the proof". 62.09 percentages of total variation in items and variation related to scale were clarified by these factors. Then scores taken by each items and all of the scale were compared and total-item correlation coefficients of items calculated. Pearson correlation coefficients of the items in the scale were changing between .50 and .78. Items were sampling similar behaviors and inner coherency of this scale was seen higher. These values were higher than .30 so that it was understood that these 21 items were appropriate for taking to this scale. Item analyses were made for distinctiveness of items and scores taken by scale were arranged ascendingly. By computing "t" values of mean scores of 27 percentages of subgroups and uppergroups, distinctiveness of items were attained (Büyüköztürk, 2006:171). Item-total correlations of each items were changing between .50 and .82 and t values were found significant ($p < .001$). Thereby reliabilities of items were found higher and measuring the same behavior. This finding specified that items were discriminating teacher candidates on account of attitudes towards proving and general aspect to the proof and also validity of construction of the scale was provided.

Reliability of the scale was analyzed. Cronbach Alpha reliability coefficient of the whole scale was found as .897 and Cronbach Alpha reliability coefficients of attitudes towards proving (factor 1) and general aspect to proof (factor 2) were respectively were found as .87 and .89 and these values demonstrated that the scale was reliable.



4. FINDINGS (BULGULAR)

The analysis of data collected from teacher candidates were given in two ways as the descriptive statistics and interpretative statistics to find answers to research problems.

4.1. Descriptive Statistics (Betimsel İstatistik)

In this part of the research, frequency (f) and the percentage (%) values which are belonging to the variables of the school year and the gender of the teacher candidates were presented.

Table 1. Frequency and percentage distribution of gender
(Tablo 1. Cinsiyete değişkenine göre frekans ve yüzde dağılımı)

Gender	Frequency (f)	Percentage (%)
Female	65	39.4
Male	100	60.6
Total	165	100

The distribution of gender of teacher candidates as shown in the Table 1, 65 female and 100 male, in total 165 teacher candidates were involved into this research.

Table 2. Frequency and percentage distribution of school year
(Tablo 2. Öğretim yılı değişkenine göre frekans ve yüzde dağılımı)

School Year	Frequency (f)	Percentage (%)
1 st Year	95	57.6
3 rd Year	70	42.4
Total	165	100

The distribution of school year of teacher candidates as shown in the Table 2, 95 teacher candidates from 1st year and 70 teacher candidates from 3rd year, in total 165 teacher candidates were involved into this research.

4.2. Interpretative Statistics (Yorumlayıcı İstatistik)

The data taken from the teacher candidates to research whether the scores of attitudes towards mathematical proof and proving changed between female and male candidates or changed between candidates from 1st year and 3rd year, were analyzed statistically.

4.2.1. Findings Related to the First and Second Subproblems (Birinci ve İkinci Alt Probleme İlişkin Bulgular)

In this part, the scores of elementary mathematics teacher candidates' attitudes towards mathematical proof and proving were analyzed by using t-test for independent samples whether there was a meaningful difference between teacher candidates from 1st year and from 3rd year and between female and male teacher candidates in 0,05 meaningfulness level.

Table 3. Findings related to the scores of attitudes towards mathematical proof and proving
(Tablo 3. Matematiksel ispat ve ispat yapmaya yönelik tutum puanlarına ilişkin bulgular)

School Year	N	Mean (\bar{X})	Standard Deviation (SS)	df	t	p
1 st Year	95	76.31	13.38	16	3.549	.001*
3 rd Year	70	69.34	11.10	3		

*p<.05



As seen in Table 3, it was found that there was a difference between the mean scores taken from the attitude scale in favor of the first year teacher candidates. T-Test for independent samples through the SPSS 12.00 program was used to understand the difference was meaningful. The value of t was found as 3.549. From the analysis, it was seen that there was a meaningful difference between mean scores in %95 confidence interval because the value of p was 0,001 and $p \leq 0.05$. In the other words, there was a meaningful difference between teacher candidates' attitudes of towards proof and proving in favor of 1st year teacher candidates.

Table 4. Findings related to the scores of attitudes of towards mathematical proof and proving
(Tablo 4. Matematiksel ispat ve ispat yapmaya yönelik tutum puanlarına ilişkin bulgular)

Gender	N	Mean (\bar{X})	Standard Deviation SS	df	t	p
Male	100	70.30	11.84	163	-3.938	.000*
Female	65	78.06	13.13			

* $p < .05$

As seen in Table 4, it was found that there was difference between the mean scores taken from the attitude scale in favor of the female teacher candidates. T-Test for independent samples through SPSS 12.00 program was used to understand the difference was meaningful. The value of t was found as -3.938. From the analysis it was seen that there was a meaningful difference between mean scores in %95 confidence interval because the value of p was 0.000 and $p \leq 0.05$. In the other words, it was understood that there was a meaningful difference between teacher candidates' attitudes towards proof and proving in favor of female teacher candidates.

4.2.2. Findings Related to the Third Subproblems (Üçüncü Alt Probleme İlişkin Bulgular)

The results of MANOVA over the scores of attitude towards proving and general aspects to proof, in terms of the factors of attitudes of the 1st year and 3rd year teacher candidates, revealed meaningful differences [Wilks Lambda (Λ)= 0.927, $F(2.163)= 6.394$, $p < .05$]. This finding indicated that scores obtained from the linear component consisted of the scores of attitude towards proving and general aspects to proof were changing according to the school year.

According to the mean score and the standard deviation values of the attitude scale which are related to two factors and school year and the results of one-way ANOVA made by factor basis, it was found that scores of attitude towards proving and general aspects to proof showed significantly difference. Scores of attitude towards proving and general aspects to proof of 1st year teacher candidates were higher than the scores of attitude towards proving and general aspects to proof of 3rd teacher candidates.



Table 5. Mean score and standard deviation values related to the scores of attitude towards proving and general aspects to proof according to the school year ANOVA results

(Tablo 5. Öğretim yılı değişkenine göre ispat yapmaya yönelik tutum ile ispata genel bakış puanlarına ait ortalama puanlar ve standart sapma değerleri ve ANOVA sonuçları)

Variable	School Tear	N	Mean (\bar{X})	Standard Deviation SS	df	F	p
Attitude Towards Proving	1 st year	95	38.33	6.30	1-163	7.586	.007
	3 rd year	70	35.68	5.83			
General Aspects to Proof	1 st year	95	37.97	8.54	1-163	11.955	.001
	3 rd year	70	33.65	7.02			

4.2.3. Findings Related To The Fourth Subproblems (Dördüncü Alt Probleme İlişkin Bulgular)

The results of MANOVA over the scores of attitude towards proving and general aspects to proof, in terms of the factors of attitudes of the 1st year and 3rd year teacher candidates, revealed meaningful differences [Wilks Lambda (Λ)= 0.907, $F(2,163)= 8.343$, $p < .05$]. This finding indicated that scores obtained from the linear component consisted of the scores of attitude towards proving and general aspects to proof were changing according to the gender.

Table 6. Mean score and standard deviation values related to the scores of attitude towards proving and general aspects to proof according to the gender and ANOVA results

(Tablo 5. Cinsiyet değişkenine göre ispat yapmaya yönelik tutum ile ispata genel bakış puanlarına ait ortalama puanlar ve standart sapma değerleri ve ANOVA sonuçları)

Variable	School Tear	N	Mean (\bar{X})	Standard Deviation SS	df	F	p
Attitude Towards Proving	Male	100	36.15	6.15	1-163	7.673	.006
	Female	65	38.84	6.04			
General Aspects to Proof	Male	100	34.15	7.45	1-163	16.466	.000
	Female	65	39.14	8.38			

According to the mean score and the standard deviation values of the attitude scale which are related to two factors and school year and the results of one-way ANOVA made by factor basis, it was found that scores of attitude towards proving and general aspects to proof showed significantly difference. Scores of attitude towards proving and general aspects to proof of female teacher candidates were higher than the scores of attitude towards proving and general aspects to proof of male teacher candidates.

5. CONCLUSION AND SUGGESTIONS (SONUÇ VE ÖNERİLER)

At the end of the t-test for independent samples it was found that school year and gender were effective on the scores taken from attitude scale of teacher candidates. This finding was similar to the findings of Senk and Usiskin, 1983; Friedman, 1989; Hyde, Fennema and Lamon, 1990; Küchemann & Hoyles, 2003, Heinze, Ufer & Reis, 2007; Almeida, 2003; De Villiers, 1990; Jones, 2000; Özer and Arıkan, 2002; Raman, 2003.



According to the MANOVA analysis, it was found that the scores of "attitude towards proving" and "general aspects to proof" of 1st year mathematics teacher candidates were significantly different from 3rd year mathematics teacher candidates. From the analysis of the scores of "attitude towards proving" and "general aspects to proof", it was found that gender and school year were effective on the factors of the scale. It was determined that the scores of "attitude towards proving" and "general aspects to proof" of 1st year mathematics teacher candidates and females' "attitude towards proving" and "general aspects to proof" scores were higher. Therefore, it was thought that those could have been effective on this conclusion: 1st year teacher candidates had already met the concept of proof and had been much more willing to prove and 3rd year teacher candidates had met comprehensive theorem proofs and had been forced open proving. This finding was related to the findings of studies of Harel and Sowder, 1998; Balacheff, 1988; Chazan, 1993; Porteous, 1990; Senk, 1985).

Proving has an important place in thinking by logical way, realizing to prove by the specific aspects of mathematics, estimating and researching mathematically, improving the mathematical reasons and mathematical proofs, evaluating, achieving the skills of choosing and using different ways of logical thinking and different kinds of proofs. Forming to prove at learner would improve the skill of mathematical understanding and provide students to understand the concepts better, believe the results and to see the things made by mathematicians and mostly important that it would change the structure of mathematical thinking.

The number of studies on mathematical proving and proof need to be increased. Teacher candidates should be provided with opportunities to develop their mathematical reasoning and proof abilities. The skill of proving should have been earned to the teacher candidates. Therefore, positive changes should be constructed in their attitudes towards mathematical proof and proving. The faculty members have to give importance to proof, reserve time for proof, show an accuracy of a theorem by using different methods of proving all together and encourage their students in this aspect. If the faculty members made the studies related to prove the theorems which were wanted from students to use in their lectures, students could have conceptual understanding and it would cause to students to be self-efficiency at mathematics courses. This would cause to the development of new mathematical thinking and changement of aspects to the conception of proof in teacher candidates' mind. The methods of proof in mathematics are valid and reliable instrument to show an accuracy of a result and also will have an effect on daily events looking by logically.

These are proposed for further studies;

- elementary and secondary mathematics teacher candidates' attitudes towards mathematical proof and proving should be compared,
- Teacher candidates from faculty of education and Art & science should be compared,
- Data taken from this research could be supported by an inquiry with open-ended questions,
- The number of studies in this subject should be increased.

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