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Prospective Mathematics Teachers' Beliefs about the Teaching of Mathematics

Matematik Öğretmen Adaylarının Matematiğin Öğretimi ile İlgili İnançları

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Abstract

The purpose of this study was to investigate prospective mathematics teachers' beliefs about the teaching of mathematics. The research was conducted on 79 fourth year students enrolled at the Mathematics Teacher Education programs at Middle East Technical University and Gazi University. A 'Beliefs about the Teaching of Mathematics Scale' was developed by the researchers. The design of the present study is that of a cross-sectional survey. The results of the study indicate that: 1. there is a statistically significant difference between the mean scores of prospective mathematics teachers at METU and those at Gazi University in terms of beliefs about the teaching of mathematics, and 2. there is no statistically significant difference between the mean scores of males and females in terms of beliefs about the teaching of mathematics.

Key Words: Prospective mathematics teacher, beliefs, teaching mathematics

Öz

Bu çalışmanın amacı, matematik öğretmen adaylarının matematiğin öğretimi ile ilgili inançlarını araştırmaktır. Araştırma, Orta Doğu Teknik Üniversitesi ve Gazi Üniversitesi dördüncü sınıfta okuyan 79 matematik eğitimi öğrencisiyle yürütülmüştür. Matematiğin Öğretimi İle İlgili İnançlar Ölçeği araştırmacılar tarafından geliştirilmiştir. Bu çalışma, bir kesitlemesine izleme araştırmasıdır. Çalışmanın sonuçları şunları göstermektedir: 1.Matematiğin öğretimi ile ilgili inançlar açısından ODTÜ ve Gazi Üniversitesinde okuyan matematik öğretmen adaylarının ortalamaları arasında istatistiksel olarak anlamlı bir fark bulunmaktadır; 2. Matematiğin öğretimi ile ilgili inançları açısından erkeklerle kızların ortalamaları arasında istatistiksel olarak anlamlı bir fark yoktur.

Anahtar sözcükler: Matematik öğretmen adayı, inançlar, matematik öğretimi

Introduction

In the past four decades, the focus of attention in research on teaching has changed (Manouchehri, 1997). The research on teacher thinking suggests that another perspective is required for understanding teacher behavior, a perspective which focuses on the things and the ways that teachers believe (Pajares, 1992).

Although "teacher's beliefs" is a popular research topic, the concept of belief has not been dealt with in a substantial way in the educational research literature, and researchers have assumed that readers know what beliefs are (Thompson, 1992). In fact the concept of beliefs needs to be defined properly before any further research is carried out. According to Pajares (1992) the construct of beliefs is a messy construct that needs to be cleaned up. Despite the absence of a consensus on a concrete definition of beliefs, there exist several definitions. In the present study the concept of "beliefs" is used in the sense defined by Ernest (1989). In this view, "beliefs" are conceptions, values, ideology, and dispositions.

In order to understand beliefs about the nature of teachers, about teacher education and about the classroom, investigation of the reasons for these beliefs

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is necessary in the world of pre-service teacher education (Lasley,1980). According to Pajares (1992) many researchers have agreed that teachers' beliefs influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, and understanding the belief structures of teachers and teacher candidates is essential for improving their professional preparation and teaching practices. Teachers' beliefs, views and preferences about mathematics and its teaching play a very important role in shaping the teachers' characteristic patterns of instructional behavior (Thompson,1984). What teachers believe about mathematics and the teaching of mathematics influences what they do in the classrooms, and what the teacher does in the classroom influences students' beliefs about mathematics (Carter and Norwood, 1997). When attention focuses on efforts to improve the ways candidates will ultimately act in their classrooms, curriculum planners in teacher education must also consider educational dispositions and beliefs (Brousseau and Freeman, 1988).

In Turkey the number of studies on beliefs about mathematics is very small (Aksu, Demir and Sümer, 1998). Aksu, Demir and Sümer gave examples related to studies on students' and teachers' beliefs about mathematics. They also provided recommendations to increase students' mathematics achievement. One of them is to change prospective teachers' beliefs about mathematics because their beliefs could affect their students' beliefs when they become a teacher.

Research on beliefs is a very new area in Turkey. In this specific case, "mathematical beliefs of prospective mathematics teachers" stands as an almost untouched concept.

Consequently, the purpose of the present study is to investigate prospective mathematics teachers' beliefs about the teaching of mathematics. This study is related to one part of Baydar's (2000) master's thesis study.

Method

Research Questions and Hypotheses

The main question of the present study is: "What are prospective mathematics teachers' beliefs about the teaching of mathematics? (BaToM)".

Based on the main question, the following sub-questions are explored:

- Sub-question 1: Is there any statistically significant difference between the mean scores of prospective mathematics teachers at Middle East Technical University and Gazi University in terms of BaToM?
- Sub-question 2: Is there any statistically significant difference between the mean scores of males and females in terms of BaToM?

The following null hypotheses are stated in order to investigate the sub-questions. They are tested at significance level of 0.05. The hypotheses of the sub-questions are stated as follows:

- There is no statistically significant difference between the mean scores of prospective mathematics teachers at the METU and those at Gazi University in terms of BaToM.
- There is no statistically significant difference between the mean scores of males and females in terms of BaToM.

Research Design

For this study survey research techniques were utilized: three major characteristics of a survey research can be found here (Fraenkel & Wallen, 1996):

- Information was collected from a group of prospective mathematics teachers in order to describe their beliefs.
- The main method employed to collect the information was asking questions. The answers to these questions constituted the data of the study.
- Information was collected from a sample rather than from every member of the population.

The design of the present study was a "cross-sectional survey". It helps obtain information from a sample that has been drawn from a predetermined population and the information is collected at just one point in time (Fraenkel & Wallen, 1996).

Subjects of the Study

The subjects of the present study consisted of 79 fourth year students enrolled on the mathematics teacher education programs of Gazi University and Middle East Technical University in Ankara, Turkey. 40 of these prospective teachers are from Middle East Technical

University and 39 of them are from Gazi University. 54 of the subjects were males and 25 were females. The convenience-sampling method was utilized to select subjects.

Definition of Terms

The definitions of terms used in this study are given below to clarify the terms and to avoid possible semantic difficulties.

Beliefs: An individual's conceptions, values, ideology, dispositions, philosophies of life and philosophies of mathematics (Ernest, 1989).

In many research papers, the concept "attitudes" is mistakenly used instead of "beliefs". There is a clear distinction between "beliefs" and "attitudes". Bem (1970) defines attitudes as:

> "Attitudes are likes and dislikes. They are our affinities for and our aversions to situations, objects, persons, groups, or any other identifiable aspects of our environment, including abstract ideas and social policies."

Ernest (1989) proposes two attitude components for the teaching of mathematics. According to him the first category, the teacher's attitudes toward mathematics, includes liking, enjoyment and interest in mathematics, or their opposites, which in the extreme case can include mathephobia. The second category, the teacher's attitudes towards the teaching of mathematics, includes liking, enjoyment and enthusiasm for the teaching of mathematics, and confidence in the teacher's own mathematics teaching ability (or their opposites).

As seen in the definitions above, attitudes are somehow related to emotions and feelings. Beliefs, on the other hand, have cognitive roots. Beliefs are more questionable than attitudes. If an individual simply likes the color red, he or she does not need to have a reason for it. No one can be asked why he/she likes red. However, if he or she believes that red is the most appropriate color for women, this belief has questionable roots. Why he/she thinks so, is open to question.

Teaching of Mathematics: Everything related to the teaching of mathematics including pedagogical issues as well as its cognitive and affective dimensions.

Measuring Instrument

A 'Beliefs about the Teaching of Mathematics Scale' was developed by the researchers. The scale was used to determine prospective mathematics teachers' beliefs about the teaching of mathematics. The procedure followed in the development of the BaToM Scale is outlined below.

1. The item pool for the BaToM Scale was derived from (a) beliefs in literature about the teaching of mathematics, (b) the National Council of Teachers of Mathematics Standards (1989, 1991), and (c) observations of people's beliefs about the teaching of mathematics. The item pool consisted of 80 items related to beliefs about the teaching of mathematics. All items were written in Turkish. From this item pool, 39 items which seemed sufficient and appropriate to the researchers were selected.
2. In order to conduct a pilot study of the BaToM Scale, it was administered to 159 mathematics education students enrolled at Middle East Technical University (83) and Selçuk University (76) in the fall semester of the 1998-1999 academic year.
3. Data were analyzed using the "Statistical Packages for Social Sciences" (SPSS). The 39-item BaToM Scale was scaled on a six-point Likert Type scale: Strongly Agree, Agree, Tend to Agree, Tend to Disagree, Disagree, Strongly Disagree. The positively worded items were scored starting from Strongly Agree as 6, to Strongly Disagree as 1, and negatively worded items were reversed for scoring purposes. This six-point scale was used to disallow undecided response found in five-point scales.
4. To test the construct validity of the BaToM Scale and to find its subdimensions, a factor analysis was done. According to the initial principal factor solution with iterations, the first twelve eigenvalues were 8.828, 3.014, 2.088, 1.849, 1.644, 1.484, 1.369, 1.270, 1.247, 1,106, 1.083, and 1.076. The first factor accounted for 22.636 % of the total variation in scores of the BaToM Scale. For the purpose of analyzing the factor

structure of the scale more precisely, this primary factor solution was rotated by the use of varimax rotation. The eigenvalues were obtained as 7.406, 2.382, 2.228, 1.884, 1.728, 1.647, 1.541, 1.499, 1.493, 1.475, 1.447, and 1.328. The first factor explained 18.990% of the variation of total scores of the BaToM Scale.

After examining the loadings from initial and varimax rotated factor solutions, 6 items were deleted because their factor loadings were very low. The loadings from initial and varimax rotated factor solutions supported that the BaToM Scale was unidimensional providing evidence for construct validity of the BaToM Scale. The single factor was named "general belief about the teaching of mathematics".

The alpha reliability coefficient of the 33-item BaToM Scale was found to be 0.82 with the SPSS package program. One item, related to usage of discussion method in mathematics classrooms, was added to this scale as it was considered necessary because there were items in the scale related to other basic teaching methods like lecturing, discovery learning, problem solving and cooperative learning, but no item related to discussion method.

After analysis of the pilot study, reliability analysis was done with 73 prospective mathematics teachers at METU and Gazi University in the spring semester of the 1999-2000 academic year. The alpha reliability coefficient of the 34-item BaToM Scale was found to be 0.84. Factor analysis was not accomplished with the new data because the number of subjects was not enough. The validity of the BaToM Scale was tested by factor analysis and a mathematics education researcher. The total score of the BaToM Scale was between 34 and 204.

If the authors of this study and many researchers in the literature believe that the idea stated in the item emphasizes the importance of teaching mathematics or methods of teaching which increase the success in teaching mathematics, and prospective mathematics teachers agree with the researchers, the response to the item will increase their total scores obtained from the scale. For example, if a prospective teacher thinks that teachers should give importance to the estimation of the results, this means that he/she has a belief approved by the researchers and then he/she will have high score from this item.

Results and Discussion

The first sub-question was "Is there any statistically significant difference between the mean scores of prospective mathematics teachers at Gazi University and Middle East Technical University in terms of beliefs about the teaching of mathematics?"

The hypotheses of the present study were tested by scoring items of the BaToM Scale on a six-point scale.

The hypothesis of the first sub-question ($H_0 1$) is that "There is no statistically significant difference between the mean scores of prospective mathematics teachers at METU and those at Gazi University in terms of BaToM."

After testing the hypothesis $H_0 1$ by using t-test at a significance level of 0.05, as seen in Table 1, a statistically significant difference between the mean scores of prospective mathematics teachers at the METU and those at Gazi University was found in terms of beliefs about the teaching of mathematics ($p<0.05$). The results are given in Table 1.

Table 1

Comparison of Mean Scores of Prospective Mathematics Teachers at METU and Gazi University in terms of BaToM

Variable	Group	N	Mean	SD	df	t-value
	METU	37	170.324	9.981		
BaToM					69	3.968 *
	GAZİ	34	158.882	14.118		

(*) $p<0.05$

A reason for this difference could be the different durations of practice teaching in the schools at these two universities. Prospective mathematics teachers in Gazi University take a "Teaching Practice" course for only one semester whereas the prospective mathematics teachers at the METU take "School Experience" and "Teaching Practice" courses for two semesters. This finding supports Vanayan, White, Yuen and Teper's (1997) ideas. Prospective mathematics teachers' practices in school are very important since the prospective teachers see the school setting and professional teachers with teachers' eyes and observe them, and it is also the first time that the beliefs of these young teachers start affecting their teaching practice (Vanayan, White, Yuen & Teper, 1997). This mean

difference between the universities cannot be completely explained by only one factor. To explain this difference more detailed research is required.

The second sub-question was "Is there any statistically significant difference between the mean scores of males and females in terms of BaToM?"

The hypothesis of the second sub-question ($H_0 2$) is that "There is no statistically significant difference between the mean scores of males and females in terms of BaToM."

After testing the $H_0 2$ by using t-test at a significance level of 0.05, as seen in Table 2, no statistically significant difference between the mean scores of males and females in terms of beliefs about the teaching of mathematics was found ($p>0.05$).

A reason for there having a mean difference between male and female prospective mathematics teachers with respect to beliefs about the teaching of mathematics may be that they chose the teacher education program. Both of them also took the two teaching mathematics courses.

Table 3 given in the appendix shows the frequencies and percentages of items in BaToM using a three-point scale in which "Agree" (A) in Table 3 includes "Strongly Agree" and "Agree" in the BaToM, "Undecided" (UD) in Table 3 includes "Tend to Agree" and "Tend to Disagree" in BaToM and finally "Disagree" (DA) in Table 3 includes "Strongly Disagree" and "Disagree" in BaToM. In order to interpret the findings easily a three point-scale was utilized in order to increase the number of subjects in the corresponding cells.

As seen in Table 3, some prospective mathematics teachers enrolled at the mathematics education programs of METU and Gazi University do not have definite, clear cut beliefs about the teaching of mathematics generally (see the appendix). Their answers for some items were generally accumulated around the categories "Tend to Agree" and "Tend to Disagree", can be reduced to one category named "Undecided".

Recommendations

The present study intended to provide an idea about the beliefs of prospective mathematics teachers or a map of "surface beliefs". This subject requires more detailed research. First of all the sample size must be increased in further studies. To be able to talk about Turkey in general, subjects from different universities from different geographical regions should be selected. Secondly, using scales and questionnaires may provide an idea or a map of surface beliefs of subjects but for a "deep" investigation of beliefs, qualitative methods of research should be employed.

As suggested by Raymond and Santos (1995) prospective teachers should experience early and continuous challenges to their beliefs so that they may become more aware of relationships between classroom experiences and beliefs. In order to realize this, time spent in the school as a student teacher should be increased. At the same time they should have intensive teaching experience during "Practice Teaching" courses.

Table 2

Comparison of Mean Scores of Males and Females in terms of BaToM

Variable	Group	N	Mean	SD	df	t-value
BaToM	Females	23	166.522	11.959	69	0.730
	Males	48	164.042	14.118		

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APPENDIX

Table 3
Frequencies and Percentages of Responses Given to Each Item of the BaToM Scale

	METU			Gazi Univ.			Total		
	A	UD	DA	A	UD	DA	A	UD	DA
Item No	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
	38	2	0	37	2	0	75	4	0
1	(95)	(5)	(0)	(95)	(5)	(0)	(95)	(5)	(0)
	2	3	35	4	8	27	6	11	62
2	(5)	(8)	(88)	(10)	(21)	(69)	(8)	(14)	(79)
	33	13	5	10	14	14	32	27	19
3	(55)	(33)	(13)	(26)	(36)	(36)	(41)	(34)	(24)
	40	0	0	38	1	0	78	1	0
4	(100)	(0)	(0)	(97)	(3)	(0)	(99)	(1)	(0)
	1	13	37	3	9	27	4	11	64
5	(3)	(5)	(93)	(8)	(23)	(69)	(5)	(14)	(81)
	39	0	1	37	2	0	76	2	1
6	(98)	(0)	(3)	(95)	(5)	(0)	(96)	(3)	(1)
	2	0	38	2	8	29	4	9	66
7	(5)	0)	(95)	(5)	(21)	(74)	(5)	(11)	(84)
	40	0	0	36	2	0	76	2	0
	(100)	(0)	(0)	(92)	(5)	(0)	(96)	(3)	(0)
	2	0	38	37	2	0	76	2	0
9	(5)	(0)	(95)	(95)	(5)	(0)	(96)	(3)	(0)
	40	0	0	2	8	29	4	8	67
10	(100)	(0)	(0)	(5)	(21)	(74)	(5)	(10)	(85)
	40	0	0	38	1	0	78	1	0
11	(100)	(0)	(0)	(97)	(3)	(0)	(99)	(1)	(0)
	40	0	0	36	3	0	76	3	0
12	(100)	(0)	(0)	(92)	(8)	(0)	(96)	(4)	(0)
	38	2	0	36	3	0	74	5	0
13	(95)	(5)	(0)	(92)	(8)	(0)	(94)	(6)	(0)

Item No	METU A n (%)	METU UD n (%)	METU DA n (%)	Gazi Univ. A n (%)	Gazi Univ. UD n (%)	Gazi Univ. DA n (%)	Total A n (%)	Total UD n (%)	Total DA n (%)
	1	6	33	6	16	17	7	22	50
14	(3)	(15)	(83)	(15)	(41)	(44)	(9)	(28)	(63)
	3	3	34	0	10	29	3	13	63
	(3)	(15)	(83)	(15)	(41)	(44)	(9)	(28)	(63)
	3	3	34	0	10	29	3	13	63
15	(8)	(8)	(85)	(0)	(26)	(74)	(4)	(17)	(80)
	40	0	0	37	2	0	77	2	0
16	(100)	(0)	(0)	(95)	(5)	(0)	(98)	(3)	(0)
	32	6	2	18	13	8	50	19	10
	(80)	(15)	(5)	(46)	(33)	(21)	(63)	(24)	(13)
	35	4	1	24	11	4	59	15	5
18	(88)	(10)	(3)	(62)	(28)	(10)	(75)	(19)	(6)
	39	0	1	34	5	0	73	5	1
19	(98)	(0)	(3)	(87)	(13)	(0)	(92)	(6)	(1)
	1	7	32	6	17	16	7	24	48
20	(3)	(18)	(80)	(15)	(44)	(41)	(9)	(30)	(61)
	36	4	0	30	8	0	66	12	0
21	(90)	(10)	(0)	(77)	(21)	(0)	(84)	(15)	(0)
	3	12	25	16	10	12	19	22	37
22	(8)	(30)	(63)	(41)	(26)	(31)	(24)	(28)	(47)
	27	13	0	25	13	0	52	26	0
23	(68)	(33)	(0)	(64)	(33)	(0)	(66)	(33)	(0)
	37	2	0	36	3	0	73	5	0
24	(93)	(5)	(0)	(92)	(8)	(0)	(92)	(6)	(0)
	40	0	0	35	3	1	75	3	1
	(100)	(0)	(0)	(90)	(8)	(3)	(95)	(4)	(1)
	40	0	0	35	3	1	75	3	1
25	(100)	(0)	(0)	(90)	(8)	(3)	(95)	(4)	(1)
	25	8	7	16	14	9	41	22	16
27	(63)	(20)	(18)	(41)	(36)	(23)	(52)	(28)	(20)
	28	10	2	15	19	4	43	29	6
28	(70)	(25)	(5)	39)	(49)	(10)	(54)	(37)	(8)
	31	9	0	29	9	1	60	18	1
29	(78)	(23)	(0)	(74)	(23)	(3)	(76)	(23)	(1)
	3	12	25	3	13	23	6	25	48
30	(8)	(30)	63)	(8)	(33)	(59)	(7)	(32)	(1)
	26	13	1	17	14	7	43	27	8
32	(65)	(33)	(3)	(44)	(36)	(18)	(54)	(34)	(10)
	32	8	9	24	14	1	56	22	1
33	(80)	(20)	(0)	(62)	(36)	(33)	(71)	(28)	(1)
	1	2	37	4	7	28	5	9	65
34	(3)	(5)	(93)	(10)	(18)	(72)	(6)	(11)	(82)

(*) A: Agree, UD: Undecided, DA: Disagree