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A SCALE FOR MATHEMATICS AND MATHEMATICAL VALUES OF PRE-SERVICE TEACHERS

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***Abstract**: Mathematics, contrary to social sciences, is seen by many, as value-free. Implications of different theories on teaching and learning applied to education including mathematics education opened doors to see mathematics in a way that it has its own values. Values can be categorized into three categories: general educational values, mathematical values (rationalism/objectivism, control/progress, openness/mystery), and mathematics educational values (accuracy, clarity, conjecturing, consistency, creativity, effective organization, enjoyment, flexibility, open mindedness, persistence, systematic working). These values are present implicitly rather than explicitly in mathematics classrooms. Teachers demonstrate these values during instruction intentionally or unintentionally.*

The purpose of the study is to develop a scale to categorize these values into two main categories: constructivist and objectivist mathematics and mathematics educational values. A 40-item scale, a five degree scale, was prepared and applied to pre-service teachers registered to the department of primary school, mathematics and science teaching. The sample of the study involves 214 participants from the department of elementary school (n = 101), mathematics teaching (n = 66) and department of science (n = 47). The principal component factor analysis is applied to verify factor loadings of the mathematical and mathematical educational values. Two main factors, namely positivist and constructivist values, were detected according to results. The items of the scale are reduced to 34. Twenty of 34 items were loaded to constructivist and 14 of 34 items were loaded to positivist mathematics and mathematics educational values. Rest of the items, which were loaded correlated weakly (test item correlation coefficient is less then 0.30), were extracted from the scale. The mean scores of pre-service teachers indicates that the men scores of constructivist values (M= 3.97; SD=0.43) is higher than the mean scores of positivist values (M=2.85; SD=0.52) in general. It is also found that there were no significant differences among mean scores of the departments. Some implications of the findings will be discussed.

INTRODUCTION

Values form affective domain of teaching-learning process. They are taught implicitly or explicitly in all school subjects. The school subject of mathematics, contrary to others, is seen by many as value-free (Bishop, 1998). This belief is not hold just by teachers, but by parents, mathematicians as well (Ellerton & Clements, 1989). Improvement of quality of mathematics educations is possible only if they are taken into the consideration.

Values can be categorized into three sub-categories: General educational values, mathematics values and mathematics educational values (Bishop, 1996). The focus of this paper will only be on mathematics and mathematics educational values since general educational values might be considered within other school subjects. Mathematical values are produced by mathematician

grown up in different cultures (Bishop, et. al., 1999). Bishop put mathematical values taught in western culture into three categories: Rationalism-objectivism, control-progress and openness-mystery (Bishop et. al., 2000). These values imply the following mathematical educational values: accuracy, clarity, conjecturing, consistency, creativity, effective organization, enjoyment, flexibility, open mindedness, persistence, systematic working. For the sake of the argument, these values might be put under two main categories, namely positivist and constructivist values. Teacher-centered and student centered teaching practices reflect these values. Objectivity, control, mystery, accuracy, clarity etc. values might be put under positivist values: rationalism, progress, openness, creativity, enjoyment, flexibility, open mindedness etc. values might be put under constructivist values. For example, if teachers believe that mathematics is a set of unquestionable truths, then they will ask from their students to practice rules and procedures.

In this study, a scale is developed to reveal these values. The scale is aimed to give an insight about teachers' conceptions and beliefs about mathematics and mathematics teaching. Even though the influences on the teaching-learning process are complex, there is a need to develop a tool for teachers to be aware of their beliefs. Teachers' awareness about these values will give them direction on their classroom practices (Thompson, 1989, 1992; Lerman, 1986).

In literature, there are a few studies aiming to develop a questionnaire (Moreira, 1992; Serrazina, 2005). The goal of this study is to develop a scale to determine mathematics and mathematics educational values of pre-service teachers. In the development of the scale these values were put into two sub-categories, namely positivist and constructivist values. This scale can be used to reveal values that pre-service teaches hold. Therefore, awareness of their values may guide them on their practices. This kind of scale may also guide the developers of teacher education programs. Beside of the developing a scale, the following research questions were also investigated:

1) What kind of values that pre-service teachers hold?
2) Are there any significant differences between pre-service teachers registered at different departments in terms of positivist and constructivist mathematics and mathematics educational values?
3) Are there any significant differences between male and female pre-service teachers in terms of positivist and constructivist mathematics and mathematics educational values?

METHOD

A survey method was conducted to investigate the research questions.

Participants

Pre-service teachers majoring in mathematics education, science education and elementary school teacher education of a university in suburban area, in Turkey, were invited to participant to the study. Table 1 gives descriptive statistics of the participants.

Table 1
Descriptive Statistics for the Participants

Age	Frequency	Percent	Cumulative Percent
22,00	145	67,8	67,8
23,00	42	19,6	87,4
24,00	27	12,6	100,0
Total	214	100,0	
Gender			
Male	94	43,9	43,9
Female	120	56,1	100,0
Total	214	100,0	
Department			
Mathematics	66	30,8	30,8
Science	47	22,0	52,8
Elementary	101	47,2	100,0
Total	214	100,0	

Instrumentation

A 40-item scale, a five degree scale, was prepared and applied to pre-service teachers registered to the department of primary school, mathematics and science teaching. Before administering the scale, construct and face validity scale is determined by three subject specialists. According to their opinions, some of the items were reconstructed. The principal component factor analysis is applied to verify factor loadings of the mathematical and mathematical educational values. Two main factors, namely positivist values (Postval) and constructivist values (Constval), were detected according to results. Twenty of 40 items were loaded to constructivist and 14 of 40 items were loaded to positivist mathematics and mathematics educational values. The final version of the scale included only 34 items. Rest of the items, which were loaded correlated weakly (test item correlation coefficient is less then 0.30), were extracted from the scale. The internal consistency of the scale was estimated by performing Cronbach's alpha. According to results overall internal consistency is calculated 0.73. The internal consistency coefficient for positivist mathematics and mathematics educational values was calculated as 0.64. The internal consistency coefficient for constructivist values was calculated as 0.74. A Pearson correlation coefficient was performed between two sub-constructs and yielded the value of 0.20. Last form of the scale is given in Appendix A.

FINDINGS AND DISCUSSION

Research questions ***1.*** "What kind of values that pre-service teachers hold?"
2. "Are there any significant differences between pre-service teachers registered at different departments in terms of positivist and constructivist mathematics and mathematics educational values?"

The mean scores of pre-service teachers indicates that the mean scores of constructivist values (M= 3.97; SD=0.43) is higher than the mean scores of positivist values (M=2.85; SD=0.52) in general (see Table 2). A t-test was performed to detect mean differences between these two sub-categories. There was significant differences between two sub-categories in the favor of the sub-category of constructivist values (t_{213} = 27.17). One way ANOVA is performed to determine if there is any significant difference among the mean score of pre-service teachers in terms of their departments. Table 2 indicates that there are no significant differences among mean scores of positivist and constructivist values of pre-service teachers in terms of their departments.

Table 2

Descriptive Statistics and ANOVA Summary Table of Constructivist and Positivist Values of Pre-Service Teachers in Terms of Their Departments

	Department	N	Mean	Std. Deviation	df	F	Sig.
Postval	mathematics	66	2,83	,56	2;211	,743	,477
	Science	47	2,82	,44			
	Elementary	101	2,89	,57			
	Total	214	2,85	,52			
Constval	mathematics	66	3,95	,44	2;211	1,897	,153
	Science	47	3,96	,41			
	Elementary	101	3,99	,43			
	Total	214	3,97	,43			

$p<0.05$

Although there is no significant difference between two sub-categories, the mean scores of constructivist values is significantly higher than the means scores of positivist values. Even though one might expect that there might be variations among departments, there is no significant difference among departments in this study. The reason for this result might be due to fact that participants took similar courses from same instructors.

Research question 3. "Are there any significant differences between male and female pre-service teachers in terms of positivist and constructivist mathematics and mathematics educational values?"

A t test was applied to detect if there is any significant difference between male and female pre-service teachers in terms of positivist and constructivist values of mathematics and mathematics educational values. Table 3 shows the descriptive statistics and t-test results. According to results, There is no significant difference between male and female participants in terms of the positivist and constructivist values. However, there is a significant difference in favor of female pre-service teachers if positivist values are taken into consideration. .

Table 3

Descriptive Statistics and t-test Summary Table of Constructivist and Positivist Values of Male and Female Pre-Service Teachers

	Gender	N	Mean	Std. Dev.	df	t	Sig. (2-tailed)
Postval	Male	94	2,85	,54			
	Female	120	2,61	,52	212	3,23	,001
Constval	Male	94	3,85	,40			
	Female	120	3,88	,43	212	-,58	,557

It seems that female pre-service teacher tend to hold more constructivist values towards mathematics and mathematic education. The reason behind this tendency might be their educational backgrounds or their own personal preferences. Even though male and female

participants tend to hold constructivist values, female participants seem to have more constructivist values than male participants if only positivist values are taken into consideration.

A standard scale is developed for the researchers to investigate mathematics and mathematics educational values of pre-service teacher from two different points of views, positivism and constructivism. This scale can also be used to investigate gender issues in terms of mathematics and mathematics educational values. The following recommendations could be made in the line with the findings of this study.

1. The scale could be applied to pre-service teachers registered at different universities.
2. The scale might be used for in-service teachers as well. The findings of applying this scale to in-service teacher may reveal their values and guide them to reconstruct their teaching practices.
3. The scale might be applied to both pre-service and in-service teachers at the same time to reveal what kind values with which they leave the school and what kind of values they practice in their classrooms.

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Appendix A

MATHEMATICS AND MATHEMATICS EDUCATIONAL VALUES SCALE

Items	1 2 3 4 5
1. Finding the correct solution of a problem should be emphasized in mathematics teaching.	
2. The straight teaching of mathematical concepts and relations is the main task of a mathematics teacher.	
3. New subjects in mathematics cannot be learned without knowing previous subjects	
4. The essence of mathematics learning is to learn mathematical concepts and relations to solve routine and non-routine problems.	
5. Mathematics is a thinking tool which is developed to fulfill people's needs.	
6. Mathematics is an activity based on creativity such as art.	
7. Mathematics can be understood only by people who are clever.	
8. The essence of school mathematics is to develop problem solving skills of students.	
9. Mathematics is not new invention but is a whole discovered body of knowledge developed through history.	
10. The process of solving a problem is as import as finding the correct solution.	
11. The essence of problem solving is to prepare students to deal with their problems encountered on their daily lives.	
12. The goal of school mathematics is to develop a sense of joy and appreciation of mathematics.	
13. Mathematics in essence generates practical solutions for problems.	
14. Mathematical knowledge cannot be discussed.	
15. In mathematics teaching, estimations on solutions should be emphasized rather than paper and pencil calculations.	
16. Mathematics has a vital role on the development of civilizations.	
17. Teacher centered activities are essential in mathematics teaching.	
18. The most efficient mathematic teaching is only possible when the logic behind rules and procedures are understood.	
19. Students should try to understand teacher's explanations instead of making sense out mathematical concepts and relations at hand on their own.	
20. Most of the jobs require mathematical thinking rather than mathematics itself.	
21. Teacher is the main source of mathematical knowledge.	
22. Mathematical knowledge has cultural aspects.	
23. Students learn not only from their correct solution but also learn from their mistakes.	
24. In mathematics teaching, activities should be designed in a way that students are actively involved.	
25. The essence of mathematics teaching is to enable students to discover mathematical concepts and relations.	
26. It is not proper that students are always in need of using concrete models in mathematics teaching.	
27. Teachers and students should construct mathematical knowledge together.	
28. In school mathematics, all students can learn basic mathematical knowledge and skills at the same level.	
29. Mathematical knowledge is necessary to be successful in a profession.	
30. Mathematics as an intellectual human endeavor is developed to solve its own problems.	
31. There is always a certain way of solving a mathematical problem.	
32. Mathematical knowledge is culture-free.	
33. The essence of mathematics learning is to learn the logic behind mathematical rules and knowledge and rules.	
34. Sequence of mathematical subjects does not have effect on learning performance.	

The items numbered 1, 2, 3, 7, 14, 17, 19, 21, 22, 26, 28, 30, 31 and 32 are assigned to positivist mathematics and mathematics educational values. The items numbered 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 18, 20, 23, 24, 25, 27, 29, 33 and 34 are assigned to positivist mathematics and mathematics educational values.