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The Beliefs of High School Students about Mathematics

Lise Öğrencilerinin Matematik Hakkındaki İnançları

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Abstract

The purpose of the study was to investigate the beliefs of high school students about mathematics. The study was conducted in Ankara with 425 tenth-grade students. The "Beliefs about Mathematics Scale" (BaMS) was used as a measuring instrument. The hypotheses of the present study were tested by using analysis of variance at a significance level of 0.05. The results of the study indicated that: 1. There were statistically significant differences among the mean scores of students enrolled in different kinds of high schools with respect to beliefs about mathematics; 2. There were statistically significant mean differences among students who had different mathematics achievement levels in terms of beliefs about mathematics; 3. There was no statistically significant mean difference between male and female students regarding their beliefs about mathematics.

Key words: Beliefs, beliefs about mathematics, gender, high school students

Öz

Bu çalışmanın amacı, lise öğrencilerinin matematik hakkındaki inançlarını araştırmaktır. Çalışma, Ankara' daki 425 10. sınıf öğrencisiyle yürütülmüştür. Ölçme aracı olarak "Matematik Hakkındaki İnançlar Ölçeği" kullanılmıştır. Bu çalışmanın hipotezleri 0.05 anlamlılık düzeyinde varyans analizi kullanılarak test edilmiştir. Çalışmanın sonuçları şunları göstermiştir: 1. Matematik ile ilgili inançları açısından farklı liselerde okuyan öğrencilerin ortalama puanları arasında istatistiksel olarak anlamlı bir fark bulunmaktadır. 2. Farklı matematik başarı seviyesine sahip lise öğrencilerinin matematik ile ilgili inançları açısından ortalama puanları arasında istatistiksel olarak anlamlı bir fark bulunmaktadır. 3. Matematik ile ilgili inançları açısından kız ve erkek öğrenciler arasında istatistiksel olarak anlamlı bir fark bulunmamaktadır.

Anahtar Kelimeler: İnançlar, matematik hakkındaki inançlar, cinsiyet, lise öğrencileri

Introduction

Mathematics is a subject that is necessary for everyday life and thus it is an integral part of the school curricula. Mathematics is also so important in many other fields that it should be studied in order to develop creativity, logical thinking and spatial abilities. For these reasons, more attention should be paid to students in order to ensure that they understand the importance of mathematics and its applications in their daily lives. Kloosterman (1999) noted that students' beliefs about mathematics were one of the factors affecting their understanding of mathematics.

Kloosterman and Stage (1992) developed a set of scales for measuring secondary school and college students' beliefs about mathematics. According to them, if mathematics instructors had an instrument related to beliefs about mathematics then they would be more willing to measure the beliefs of their students. This would allow them to determine students' beliefs so that they could modify their instruction approaches and methods so as to encourage the development of more positive beliefs among their students.

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Schoenfeld (1989) investigated the relationships between students' beliefs about mathematics and their understanding of the nature of deductive proof in geometry. The participants were 230 students enrolled in high school mathematics courses. The instrument contained 81 open-ended and closed-ended items which were related to the students' perceptions of mathematics and school practice, their views of school mathematics and the nature of geometric proofs. The results of the study showed that the students believed that the problems in mathematics had only one correct answer; that mathematics was best learned by memorization; that getting poor grades was their own fault and that effective teaching of mathematics consisted of showing students different ways to solve the same question. In a descriptive study undertaken by Vanayan, White, Yuen and Teper (1994) concerning the beliefs and attitudes toward mathematics among third and fifth grade students, the authors concluded that most students were aware of the usefulness and relevance of mathematics outside of school.

In Turkey, Aksu, Demir and Sümer (2002) carried out research related to primary students' beliefs about mathematics. The purposes of their study were to investigate what beliefs primary school students had about mathematics and to reveal any differences occurring among students' beliefs with respect to their gender, their grade and their level of achievement in mathematics. The results of the study indicated that there were significant differences between students' beliefs about mathematics with respect to their grades and their level of achievement in mathematics.

Other research dealing with gender differences related to beliefs about mathematics have shown that there are no significant differences between the beliefs of girls and boys with respect to mathematics (e.g., Baydar, 2000; Aksu, Demir and Sümer, 2002). However, there is evidence to indicate that even at a young age, boys are more positive than girls regarding their own competence in mathematics (e.g. Eccles et al, 1993). Eccles et al (1993) reported that girls and boys valued mathematics equally, but that boys were more likely to believe that they were more competent than girls with respect to their mathematical ability.

The assessment of students' beliefs about mathematics can help teachers structure the classroom environment and plan instruction in order to improve students' mathematical thinking abilities (NCTM, 1989). Aksu, Demir and Sümer (2002) noted that "the assessment of students' beliefs about mathematics can be one of the important starting points for the improvement of mathematics instruction" (p 73).

Thus, knowing students' beliefs about mathematics and the teaching of it can help to find new ways and approaches for teachers so that they may teach mathematics more effectively and also be more aware of how to behave towards their students during their lessons. In Turkey, only a little research has been carried out regarding students' beliefs about mathematics. Thus, in the present study, the aim has been to investigate the beliefs of high school students about mathematics by taking into account different kinds of high schools, students' mathematics achievement levels and gender. This study is related to one part of Mert's (2004) master thesis study.

Method

Research Questions

The main question of the present study is "What are high school students' beliefs about mathematics?". With regard to this primary aim, the following sub-questions were also explored:

P1. Are there any statistically significant differences among the mean scores of students enrolled in different kinds of high schools with respect to their beliefs about mathematics?

P2. Are there any statistically significant mean differences among students who have different mathematics achievement levels in terms of their beliefs about mathematics?

P3. Is there any statistically significant mean difference between male and female students in regard to their beliefs about mathematics?

The null-hypotheses were tested at a significance level of 0.05 in order to investigate the sub- questions.

Procedure

The subjects of the study were asked certain items related to their beliefs about mathematics. Before the instrument was administered to students in their

classrooms, the purpose of the study and the directions were explained to them. They were also informed that each item had no correct or incorrect answer, only the truth relating to each individual student, therefore each student's answer might be different from his/her classmates. The scale contained 22 items that addressed students' beliefs about mathematics. The students completed the scale in approximately 15 minutes.

Subjects of the Study

The subjects of the study were 425 tenth grade students enrolled in different kinds of schools (vocational high school, general high school, foreign language high school, and Anatolian high school) in Ankara, Turkey. 187 of the subjects were male and 238 of the subjects were female students. The distribution of the subjects with respect to the different kinds of high schools is given in Table 1

For the present study, convience-sampling was used to select the subjects.

The students' mathematics achievement levels (MAchL) were also considered in the study. The students were categorized into three groups according to their mathematics grades for the previous semester: low achieving students (Lowachv), moderate achieving students (Modachv) and high achieving students (Highachv). The students with mathematics grades of between 0,1 and 2 were categorized as low achieving students, the students with mathematics grades of 3 were categorized as moderate achieving students and the students with mathematics grades of 4 or 5 were categorised as high achieving students. The distribution of the number of the students with respect to their mathematics achievement levels is shown in Table 2.

Table 1

The Distribution of the Subjects with respect to the Different Kinds of High Schools

High school	Male	Female	Total n (%)
Vocational	47	68	115(27.1)
General	52	62	114(26.8)
Foreign L.	40	55	95 (22.4)
Anatolian	48	53	101(23.8)
TOTAL	187	238	425 (100)

Table 2

The Distribution of the Subjects with respect to their Mathematics Achievement Levels

MAchL	N	Percentage
Lowachv	180	42.4
Modachv	91	21.4
Highachv	154	36.2
TOTAL	425	100

Measuring Instrument

In the present study, the "Beliefs about Mathematics Scale" (BaMS) was administered to 10^{th} grade students in order to determine the students' beliefs about mathematics.

The procedure followed in the development of the BaMS is outlined below:

The item pool for the BaMS was derived from (a) literature related to beliefs about mathematics (b) the National Council of Teachers of Mathematics Standards (1989, 1991) (c) the BaMS developed by Baydar (2000) for preservice teachers (d) observations of students and the results of interviews with them regarding their beliefs about mathematics. The item pool consisted of 40 items related to the students' beliefs about mathematics.

The scale was administered to 210 high school students in the Fall Semester of the 2003-2004 academic year for the pilot study. The data was analyzed by using the "Statistical Packages for Social Sciences" (SPSS). The scale included 21 five-point Likert type items coded as Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree. The positively worded items were scored starting from strongly agree as 5, to strongly disagree as 1, and negatively worded items were reversed to a positive direction for scoring purposes.

To test the construct validity of the BaMS and to find its dimensions, factor analysis was performed. According to the initial principal component analysis, the first seven eigenvalues were 3.660, 1.748, 1.383, 1.330, 1.142, 1.046, and 1.027. The first factor accounted for 17.427% of the total variance and the second factor accounted for 8.325% of the total variance

in the BaMS scores. The factor loadings of the BaMS in the first factor ranged from 0.39 to 0.62. The factor loadings of the BaMS in the second factor ranged from 0.26 to 0.58.

For the purpose of analyzing the factor structure of the scale more precisely, this primary factor solution was rotated by the use of the varimax rotation. The eigenvalues were obtained as 17.427 and 8.835. The first factor explained 16.917% of the variation of total scores of the BaMS. Factor loadings of the BaMS in the first factor ranged from 0.27 to 0.67. Factor loadings of the BaMS in the second factor ranged from 0.19 to 0.59. The factor loadings with values of 0.19 or above have been presented in the appendix.

When the items accumulated in each factor (see appendix) were written in open forms, the items in Factor 1 were related to the nature of mathematics and the items in Factor 2 were related to the learning of mathematics. Thus, we named factor 1 "beliefs about the nature of mathematics" and factor 2 "beliefs about the learning of mathematics". Although the factor loading of the item "there is no need to have a good memory for mathematics" was very low (see appendix), it was also used in the scale because of the validity of the test.

The alpha reliability coefficient of the BaMS with 21 items was found to be 0.71 in the pilot study.

The item "Mathematics requires logic but not intuition." measured two different criteria, so it was divided into two items for the main study: "Mathematics requires logic" and "Mathematics requires intuition". In the main study, the alpha reliability coefficient of the scale with 22 items was found to be 0.78. The total score of the BaMS was between 22 and 110.

In addition, various experts from the field of mathematics education investigated the scale for its content validity. Moreover, the grammar of the language used in the scale was examined by mathematics and literature teachers.

Thus, the BaMS has 22 items related to students' beliefs about mathematics. To gather the data for the present study, the BaMS were administered to 425 tenth grade students in Ankara in the Spring Semester of the 2003-2004 academic year.

Results

To find out whether students' beliefs about mathematics differ according to their high schools, their mathematics achievement levels or their gender, an Analysis of Variance (ANOVA) was used by considering the total score of the BaMS as a dependent variable.

The results indicated no significant interaction effect among different kinds of high schools, mathematics achievement levels and gender on the BaMS (see Table 3).

The hypotheses of the present study were tested by scoring the items of the BaMS on a five-point scale.

In addition, the means and standard deviations of the BaMS scores were analyzed with respect to different kinds of high schools, mathematics achievement levels and gender.

The first sub-question was "Are there any statistically significant differences among the mean scores of students enrolled in different kinds of high schools with respect to their beliefs about mathematics?"

As seen in Table 3, it was found that there were statistically significant differences among the mean scores of students who were enrolled in different kinds of high schools with respect to their beliefs about mathematics ($p<0.05$).

To determine which groups caused this difference in the BaMS scores, the Tukey Test was used. The results of the Tukey Test analysis related to different high school students' beliefs about mathematics indicated that the most significant differences were found between the mean scores of students who were in foreign language and Anatolian high schools ($p<0.05$), foreign language and vocational high schools ($p<0.05$), vocational and general high schools ($p<0.05$), general and Anatolian high schools ($p<0.05$) with respect to beliefs about mathematics.

As seen in Table 4, students in general high schools had higher BaMS scores than the students in Anatolian and vocational high schools. Moreover, according to the results, students in foreign language high schools had higher BaMS scores than students in Anatolian and vocational high schools.

The second sub-question was "Are there any statistically significant mean differences among students

Table 3
Result of Analysis of Variance of the BAMS Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
High School	4245.545	3	1415.182	14.888	0.00**
MAchL	6489.674	2	3244.837	34.137	0.00**
Gender	123.840	1	123.840	1.303	0.254
Gender* High School	380.417	3	126.806	1.334	0.263
Gender* MAchL	370.072	2	185.036	1.947	0.144
High school*MAchL	646.427	6	107.738	1.133	0.342
Gender* High School* MAchL	988.519	6	164.753	1.733	0.112
Error	38116.06	401	95.053		
Total	2544312	425			

** $p<0.05$

Table 4.
Means and Standard Deviations of the BaMS Scores with respect to high schools

High School	Mean	SD
Anatolian	73.96	12.73
Foreign L.	79.17	9.67
General	78.54	10.49
Vocational	74.87	9.93

Table 5.
Means and Standard Deviations of the BaMS Scores with respect to MAchL

	BaMS	
MAchL	Mean	SD
Highachv	81.34	10.25
Modachv	74.91	9.45
Lowachv	73.39	10.85

who have different mathematics achievement levels in terms of beliefs about mathematics?"

As seen in Table 3, ANOVA results showed that there were statistically significant mean differences among students who had different mathematics achievement levels in terms of beliefs about mathematics ($p<0.05$).

According to the Tukey Test results, there were statistically significant mean differences among low and high achieving students in terms of beliefs about mathematics ($p<0.05$). In addition, there were statistically significant mean differences among high achieving and moderate achieving students in terms of beliefs about mathematics ($p<0.05$). As seen in Table 5, high achieving students had higher BaMS scores than low achieving and moderate achieving students. It was also found that there were no statistically significant mean differences among low achieving and moderate achieving students in terms of beliefs about mathematics ($p>0.05$).

As seen in Table 3 and Table 6, it was found that there was no statistically significant mean difference between male and female students in terms of beliefs about mathematics ($p>0.05$).

In Turkey, students' beliefs about mathematics have been studied by several researchers and educators to make sense of their mathematical behavior. In the present study, the students' beliefs about mathematics were investigated with respect to different kinds of high

Table 6.
Means and Standard Deviations of the BaMS Scores with respect to Gender

Gender	Mean	SD
Male	75.43	11.98
Female	77.52	9.98

school, mathematics achievement levels and gender. The null hypotheses were tested by ANOVA at a significance level of 0.05.

According to the ANOVA results, there were statistically significant differences among the mean scores of students who were enrolled in different kinds of high schools with respect to their beliefs about mathematics. Thus, it can be stated that students at different high schools had different beliefs about mathematics. This result might have occured because of external factors. These external factors could be the structure of the classrooms and the type and manner of the mathematics instruction given. These findings support Aksu, Demir and Sümer's (2002) ideas. Differences in the classroom environment and experiences may affect students' motivation and achievement which, in turn, may influence students' beliefs (Aksu, Demir & Sümer, 2002). Surprisingly, looking at the mean scores, it can be seen that students enrolled in foreign language high school had the highest mean scores. On the other hand, students in the Anatolian high school had the lowest mean scores with respect to beliefs about mathematics. Although the students in the Anatolian high school might be expected to get higher mean scores than students in other schools the findings of the study did not confirm this. This might be due to the fact that the students who entered this school might have done so on the basis of lower scores than students in the leading Anatolian high schools in Ankara.

According to the ANOVA results, there were statistically significant differences among the mean scores of students who had different mathematics achievement levels with respect to their beliefs about mathematics. Students who were high achievers received a higher score from the scale on beliefs about mathematics. Students who were successful in their mathematics lessons were able to see mathematics as an important, useful and necessary tool for other subjects and also for real life. Additionally, students who believed that mathematics was an important subject might be more highly motivated which would result in higher achievement. These findings seemed to be similar to the ideas of Kloosterman (1999) and Kloosterman and Stage (1992). Beliefs are an important factor in students' motivation to learn mathematics (Kloosterman, 1999) and increasing the students' beliefs about the usefulness of learning mathematics is related to increasing motivation and, in turn, achievement (Kloosterman & Stage, 1992). Moreover, the difference in beliefs of students with respect to achievement might be due to self-confidence. Students with high levels of self-confidence about their mathematical abilities may value mathematics more than those with low levels of self-confidence.

In the present study, it was also found that there was no statistically significant mean difference between male and female students regarding their beliefs about mathematics. This finding is consistent with the finding of Eccles et al (1993) who stated that girls and boys valued mathematics equally. In addition, Aksu, Demir and Sümer (2002) and Baydar (2000) found no statistically mean difference between male and female students in terms of beliefs about mathematics. In the present study, it can also be stated that both male and female students thought that mathematics was an important subject to learn. According to the results of the study conducted by Vanayan, White, Yuen and Teper (1994), there was no gender difference regarding the beliefs of students that not only did they need to know mathematics in order to get a good job but that also both girls and boys should learn mathematics.

Recommendations

According to the results of the study, students who were in different kinds of high schools had different beliefs about mathematics. Because of external factors such as methods of instruction and the classroom environment, students might value mathematics differently. Thus, effective instruction and good classroom environments should be provided for all students.

In addition, the beliefs of students should become a matter of concern for teacher education programs. Preservice teachers should be taught how different and more effective teaching methods can be used in classrooms in order to change students' unproductive beliefs and increase student motivation towards mathematics.

The results of the study showed that students' beliefs differed according to their mathematics achievement levels. Thus, the relation between belief and variables that affect students' achievement such as anxiety, motivation and self-confidence could be further investigated.

Moreover, if effective activities can be presented during instruction, students can see mathematics as a necessary subject both inside and outside the classroom. Thus, real-life applications should be provided to students more frequently in order to have them see mathematics as a useful and important subject.

In addition, mathematics curriculi should include activities related to discovering, analyzing and investigating to let students use their creativity and explain their mathematical ideas.

This study was conducted with only tenth grade students. Further research could be undertaken regarding the beliefs of students in different grades. In addition, for a deep investigation of students' beliefs, qualitative methods of research could be utilized.

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APPENDIX

Table 7
Results of Principal Component Analysis with Varimax Rotation for the BaMS

Item	Factor1	Factor2
Mathematics makes life easier.	0.67	
Mathematics is a way of thinking that human beings develop when they solve the problems they face in real life.	0.58	
Mathematics helps people acquire logical thinking abilities.	0.54	
Mathematics is not a tool used for the development of civilization.	0.53	
Mathematics is not necessary for society.	0.53	
Mathematics is a language.	0.51	
Mathematics helps people develop their problem solving abilities.	0.49	
Mathematics is a science that explains natural events by using numbers.	0.48	
Mathematics is a tool that helps the development of other branches of science.	0.48	
Mathematics is an art like painting, poetry or music.	0.47	
Mathematics is a game.	0.43	
There is no need for creativity in mathematics.	0.41	
Mathematics is a subject that concerns everybody.	0.33	
Mathematics has no effect on cognitive development.	0.27	
Individuals' mathematical ability can be different.		0.59
Mathematics cannot be taught to everyone.		0.56
Mathematics requires logic but not intuition.*		0.49
Mathematics is a science that only deals with numbers.		0.45
A person who doesn't like mathematics will not be able to do it.		0.37
Finding the correct answer is not the most important issue in mathematics.		0.33
It is not necessary to have a good memory for mathematics.		0.19

* In the main study, this item was divided into two: "mathematics requires logic" and "mathematics requires intuition".