Eğitim ve Bilim
2002, Cilt 27, Sayı 123 (72-77)

Education and Science
2002, Vol. 27, No 123 (72-77)

Students' Beliefs About Mathematic: A Descriptive Study

Öğrencilerin Matematik Hakkındaki İnançları: Betimsel Bir Çalışma

Meral Aksu, Cennet Engin Demir ve Zeynep Hatipoğlu Sümer
Middle East Technical University

Abstract

This study was designed to investigate primary school students' beliefs about mathematics. A sample of 563 students from two primary schols were administered the "Beliefs about Mathematics Survey (BMS)". The survey, which was developed by the researchers, included 20 items in three subscales: beliefs about the nature of mathematics, beliefs about the process of learning mathematics, and beliefs about the use of mathematics. The results indicated that there were significant differences between students' beliefs with respect to grade level and mathematics achievement. However, no significant differences were observed on the three subscales of BMS with respect to sex.

Key Words : Beliefs about maths, students beliefs.

Öz

Bu çalışma ilköğretim okulu öğrencilerinin matematik hakkındaki inançlarını belirlemek amacıyla yapılmıştır. Çalışmada iki ilköğretim okulundan katılan 563 öğrenciye Matematik Hakkındaki İnançlar Anketi (MİA)" uygulanmıştır. Araştırmacılar tarafından geliştirilmiş olan anket, matematik hakkındaki inançlar, matematik öğrenme süreci hakkındaki inançlar ve matematiğin kullanımı hakkındaki inançlar boyutları altında 20 maddeden oluşmaktadır. Bulgular öğrencilerin matematik hakkındaki inançlarının sınıf düzeyi ve matematik başarısı açısından farklı olduğunu göstermiştir. Ancak cinsiyete göre MİA'nın üç boyutunda anlamlı bir farklılık gözlenmemiştir.

Anahtar Sözcükler : Matematik hakkında inançlar, öğrenci inançları.

Introduction

Mathematics teaching is not merely related to students' achievement, and teachers' teaching approaches but also the beliefs held by them about the nature of mathematics and its teaching and learning. According to Underhill (1988) assessment of students' beliefs about mathematics and knowing how to affect them are important if we expect to improve mathematics instruction. Moreover, several researchers argue that success and failure in math often depend on much more than the knowledge of requisite mathematical content such as facts, algorithms or procedures; other factors such as decisions one makes, emotions and beliefs (Garofalo, 1989; McLeod, 1988; Schoenfeld, 1985) may also influence mathematics achievement.

Pajares (1992) argues that beliefs guide the behavior and how individuals adapt to their environment. A dynamic system of belief clusters is related to experiential context such as classroom environment. Therefore, beliefs that students have about mathematics may also result from their personal experience as participants in the mathematics classroom (Fleener, 1996). Researchers have demonstrated that beliefs influence knowledge acquisition and interpretation, task definition and selection, interpretation of course content, and comprehension monitoring (Pajares, 1992).

Students' beliefs about learning and beliefs about the nature of subject-matter affect their learning. "Students' beliefs build beliefs about what mathematics is, about

Prof. Dr. Meral Aksu, Assist. Prof. Dr. Cennet Engin Demir, Dr. Zeynep Hatipoğlu Sümer, Middle East Technical University, Faculty of Education, Department of Educational Sciences, Ankara.

what it means to know and do mathematics" (Carter & Norwood, 1997, 1). Schoenfeld (1985) described the beliefs about mathematics as one's mathematical "world view" (p.45). Students' mathematical world view influences how they study mathematics and how and when they occupy themselves with mathematics.

The effect of various variables has been investigated in studies about students' beliefs about mathematics. (A summary is provided in Aksu, Demir, & Sümer, 1999) Among them, some articles have examined the relationship between students' achievements of and their beliefs about their performances and abilities in mathematics (Doan et al. 2000; McClendon & Wigfield, 1998). On the other hand, some researchers have tried to understand the contributions of students self-confidence and self-efficacy beliefs in learning mathematics (Pajares & Miller, 1994; Austin, Wadlington & Bitner, 1992).

Gender differences in outcomes of mathematics education have been considered as important factors that create educational inequities. The issue has therefore been the focus of many research studies (Vanayan, White, Yuen, & Teper; 1997, Stipek & Gralinski, 1991; Fennema, Peterson, Carpenter, & Lubinski, 1990). According to results of these studies, girls have a more negative belief system about mathematics so they do not opt for mathematics related careers.

In parallel with the reform attempts in primary education, improvement of the math curriculum has been an important, recent discussion in Turkey. Although a considerable amount of research has been conducted on the beliefs of primary grade students on mathematics in the world, relatively little research has been completed in Turkey. The only study (Baydar, 2000) was on the beliefs of preservice mathematics teachers attending two universities where the results showed no statistically significant difference between the mean scores of girls and boys in terms of beliefs about the nature of mathematics and the teaching of mathematics. It can be derived from the literature that assessment of students' beliefs about mathematics may give a clear picture of the mathematical environment within a classroom. The assessment of students' beliefs about mathematics can be one of the important starting points for the improvement of mathematics instruction. Therefore, the present study sought to investigate primary school students' beliefs about mathematics.

This research project was designed to analyze students' beliefs about mathematics in two Turkish Primary Schools. The research questions guiding in this study were:

1. What beliefs do primary school students have about mathematics?
2. Do students' beliefs differ according to sex, grade level, and level of mathematics achievement?

Method

Sample

The participants were selected from two primary schools (one private, one public) in Ankara, Turkey. In both schools students of grades 4 to 8 were included in the study. In the private school, two classes from each grade level were selected randomly, whereas in the public school, since the classes were quite crowded, one class from each grade level was selected randomly. The final sample included 288 students (girls= 125, boys=163) from the public school and 275 students (girls = 153, boys = 122) from the private school (N= 563). The total number of girls was 278 and the total number of boys was 285.

Instrument

In order to measure the students' mathematics beliefs,"Beliefs about Mathematics Survey" (BMS) was developed by the researchers. For the purpose of developing the instrument literature regarding beliefs about mathematics and the several instruments were reviewed. Then, open- ended questions were prepared and group interviews with 16 students (2 from each grade level- one boy one girl - 8 students in each school) were conducted. Based on the literature review and interview results, the items in the survey were developed. The final form of the instrument consisted of two parts. The first part, a demographic form, included items related to name of the school, students' sex, grade level, and 1998-99 school year first semester mathematics grade. The second part included 20 statements related to beliefs about mathematics on a 4 point Likert scale ranging from "completely agree" to "completely disagree".

Principal component analysis with varimax rotation was carried out to identify the underlying dimensions that explain the responses of the students to the instrument. As intended by the researchers, results revealed three factors, which were labeled as "beliefs about the process of learning mathematics" including 10 items, (score range: 10-40) "beliefs about the use of mathematics" including 7 items (score range: 7-28), and "beliefs about the nature of mathematics" including 3 items (score range: 3-12). The "beliefs about the nature of mathematics" subscale was mainly related to the characteristics of mathematics, the "beliefs about the use of mathematics" subscale was related to the importance and use of mathematics, and the " beliefs about the process of learning mathematics" subscale included items related to how mathematics is learned, who are more successful in mathematics, and what one needs to do to be successful in mathematics. Hence, the scale measured mathematical beliefs in the three areas.

The internal consistencies of the three subscales were 0.75, 0.71 and 0.66 for "beliefs about the process of learning mathematics", "beliefs about the use of mathematics" and "beliefs about the nature of mathematics", respectively. The overall reliability coefficient was 0.75.

Procedure

The "Beliefs about Mathematics Survey" was administered to students in their classrooms in the participating schools within a one-week period during second semester of the 1998-99 academic year. In each class, the purpose of the study was explained, and the directions were read aloud to the students. Students were also assured of the confidentiality of their responses. The students the completed the survey independently, in approximately 15 minutes.

Results and Discussion

Students' Beliefs About Mathematics

The means and standard deviations of students' scores for the BMS items are given in Table 1. These items were categorized into three sections; beliefs about the process of learning mathematics, beliefs about the use of mathematics, and beliefs about the nature of mathematics.

As can be seen in Table 1, students expressed varying degrees of agreement or disagreement with the 20 statements. When the items related to the "Beliefs about the process of learning math" were examined, students mainly "agreed" with the statements, "To be successful in math, it is important to find the correct answer", "Math questions should be solved by the methods taught by the teacher" and "To be successful in math, it is necessary to solve the problems quickly and correctly". These items seem to reflect the nature of mathematics teaching in our schools. The students believe that mathematics always requires finding the correct answer, and there is only one method of solution to a problem which is taught by the teacher, and one has to be quick and correct. According to Garofalo (1989), students who held the belief that math problems should be solved by the method taught by the teacher tend to spent their time studying mathematics by memorizing the facts, formulas and practising procedures rotely. Therefore, they usually do not spent time trying to understand mathematical thinking. Parallel with this belief, it would be expected that thesestudents would also agree with the statement "To be successful in math, you need to be good at memorizing". However, there is no strong agreement with this statement. Students seemed to have contradictory beliefs about the process of learning mathematics which is consistent with the findings of a study conducted by Schoenfeld, (1985). In his study, students believed either that math required memorization or that math increased creativity.

Students disagreed with the statement that "Math is the work of a genius". They seem to believe that one does not need to be a genius in order to do well in math. So, this may indicate that these students believe that one can be successful in math if one tries and works hard. Therefore, it may be derived that they have positive beliefs about their competence, which is consistent with the findings of a study carried out by Vanayan, White, Yuen & Teper (1997).

When the items related to the "Beliefs about the use of mathematics" were examined, it was seen that students mainly agreed with all the items related to the use of mathematics. This shows that students believed in the use of mathematics and seemed to be aware of the usefullness and relevance of mathematics outside of school.

Table 1
Mean Scores and Standard Deviations for the BMS Items

Items	n^a	Mean	*SD*
Beliefs about the process of learning mathematics			
1. To be successful in math, it is important to find the correct answer	495	2.945	1.013
2. Math questions should be solved by the methods taught by the teacher.	495	2.767	1.115
3. To be successful in math, it is necessary to solve the problems quickly and correctly.	495	2.648	.978
4. To be successful in math, what is learned in the classroom is sufficient.	495	2.167	1.023
5. Math can only be learned from the teacher.	495	2.056	1.089
6. To be successful in math, you need to be good at memorising.	495	1.800	1.005
7. The exercises in a math book can only be done by using the methods given in the book.	495	1.789	.946
8. In a math course, it is sufficient to know the topics that will be asked in the exam.	495	1.692	.983
9. Using a calculator makes it easier to learn math.	495	1.622	.931
10. Math is the work of genius.	495	1.450	.820
Beliefs about the use of mathematics			
11. Math facilitates practical intelligence.	520	3.553	.719
12. Knowing math is important for all profes-sions.	520	3.394	.809
13. Math is mental practice.	520	3.294	.886
14. Math is a universal language.	520	2.978	1.032
15. Math makes everyday life easier.	520	2.967	1.007
16. Math is necessary to be successful in other courses.	520	2.575	1.015
17. Math is used in each course.	520	2.561	1.100
Beliefs about the nature of mathematics			
18. Math is numbers.	532	2.479	1.095
19. Math is problem solving.	532	2.413	1.069
20. Math is doing calculations.	532	2.396	1.060

n*: n varies due to missing cases.

Examining the items related to beliefs about the nature of mathematics, since for all the 3 items the means were around 2.4 (between disagreement and agreement), they seem to be in a transition period in forming their beliefs about the nature of mathematics.

Students' Beliefs With Respect To Sex, Grade Level And Mathematics Achievement

To find out whether students' beliefs about the nature of mathematics, the process of learning mathematics and the use of mathematics differ according to sex, grade level, and math achievement, a MANOVA was computed with three subscales by considering total scores as dependent variables. The results of the multivariate test of significance followed in the MANOVA procedure indicated no significant interaction effect of grade, sex and level of mathematics achivement on the three subscales of BMS (Hotellings $T^2 = 0.031$).

The results of the univariate F-test followed in MANOVA procedure revealed no significant difference between male and female students on "beliefs about the nature of mathematics" (F=0,774), "beliefs about the process of learning mathematics" (F= 0,273), and about the use of mathematics (F=0,620). This result seems to be confirmed with the previous findings that boys and girls have similar beliefs about math and the process of learning math (Baydar, 2000, and see Leder, 1992 for a review).

Furthermore, the univariate F-test followed in the MANOVA procedure indicated that there were significant mean differences between the grade levels on the process of learning mathematics (F=5.670, p<0.001) and the nature of mathematics (F=2.743, p<0.05) subscales. However, no significant difference was observed for beliefs about the use of mathematics with respect to grade level (F=1.326). For the purpose of identifying which grade level created the significant difference, joint univariate contrasts with a 95% Bonferroni confidence interval were carried out. The results of Bonferroni indicated that the significant

differences were between the 4th and 5th; 4th and 6th, 4th and 7th, and 6th and 8th graders' beliefs about the process of learning mathematics. For the beliefs about the nature of mathematics subscale, the significant differences were between the 4th and 6th, and 4th and 7th graders. There is some evidence that a child's attitude toward mathematics is developed through math experiences (Johnson, 1981). Therefore, changes in the classroom environment and change in the quality of experiences might have influenced the students' motivation and achievement (cited in Midgley, Feldlaufer, & Eccles, 1989), which leads to differentiation of the beliefs of students between grade levels.

Considering math achievement, students were grouped as underachievers (report card grades: 1 and 2) and achievers (report card grades: 3,4 and 5) according to their previous semester mathematics course report card grade. The univariate F-test followed in MANOVA also revealed a significant difference between achievers and underachievers in beliefs about the "process of learning mathematics", "use of mathematics" and "nature of mathematics" (F=45.681, $p<0.001$; F=4.891, $p<0.05$; and F=13.476, $p<0.01$, respectively).

Conclusion and Implications

The starting point of this study was to give a picture of the math environment within a classroom by assessing students' beliefs about mathematics. As stated by Carter and Norwood (1997) "measuring the beliefs and changes in beliefs of students can provide a snapshot of what is going on within a classroom without requiring significant measures" (p.66).

One of the interesting findings of this study indicated that students believed that they had to find the correct answer and solve math problems by the methods taught by the teacher and do these correctly and quickly. Students who hold this belief would spent their time trying to remember the methods given by the teacher rather than attempting to reason through the problem. It can be concluded that students' beliefs to some extent might be influenced by the preparation activities that they engage in for the several entrance examinations in our country. Since these exams are multiple choice exams, students are required to solve problems quickly and correctly they do not have time to find out or try their own way of solving problems. As a result, it can be observed that students' beliefs could result in false impressions about how mathematics is learned. These false impressions may lead to avoidance of math and failure in math (Frank, 1990). At the same time, we cannot expect many students to develop more realistic and healthy beliefs about mathematics. Moreover, we should be aware of the fact that these unhealthy beliefs may influence students' study habits, test taking strategies and classroom behaviors. Students generally develop these unhealthy beliefs as effective ways of dealing and coping with the demands of classroom mathematics (Garofalo, 1989; Cobb, 1986). These beliefs need to change.

One way of changing the students' beliefs is to change teaching methods. Teachers should not be setting up classroom environments that foster these unhealthy beliefs. They should encourage students to reason through the problem and find their own way of solving problems. Math teachers need to be more facilitators than transmitters of information.

Another way of changing students' beliefs might be changing the mathematics curriculum. Changing the mathematics curriculum from one that focuses on drill and practicing a number of facts and computational algorithms to one that emphasizes problem solving, estimation and conceptual understanding may lead to change in students beliefs (Frank, 1990). Teachers generally try to help students to be successful in standardized examinations in schools. As a result, they emphasize the drill and practice of computational algorithms in teaching. At the same time students tend to memorize in order to cope with the demands of standardized examinations. Therefore, changing the examination system might help students to change their beliefs about the process of learning math and also to change their study habits.

Another way to change beliefs about mathematics may be to develop students' awareness of their own other mathematical beliefs. Discussion of beliefs can be a vehicle for developing such awareness.

As one of the interesting findings of the study, students seemed to be aware of the usefullness of mathematics outside of the school. Since perceived usefulness and relevance of mathematics is thought to be an important determinant of activity choice (Eccless, Wigfield,

Harold, & Blumenfelds, 1993), it may be valuable to make mathematics relevant in primary schools, perhaps by providing students with real-life applications more frequently. Teachers need to reinforce this belief by providing a variety of examples related to students' life.

Since differences were observed between students' beliefs about the process of learning mathematics and beliefs about the nature of mathematics with respect to their grade level, the results highlight the need for conducting grade-by-grade analyses in order to understand the reasons for these differences. Also, the differences observed in all three belief areas with respect to achievement level need to be studied further.

The findings also suggested that male and female students held a "gender-free" view of mathematics. It can be predicted from the findings that students experience a "gender-free" classroom atmosphere in the two primary schools. However, there may be some factors other than classroom enviroment that have affected students' beliefs about mathematics, such as parents and peer groups. Therefore, conducting a detailed qualitative study might be necessary to analyze the classroom environment and figure out the reasons for these gender-free beliefs of students about math.

References

Aksu, M., Demir, C. ve Sümer, Z. (1999) Matematik öğretmenlerinin ve öğrencilerinin matematik hakkındaki inançları. *III. Ulusal Fen Bilimleri Eğitimi Sempozyumu. 23-25 Eylül 1998. Karadeniz Teknik Üniversitesi. Trabzon.* Ankara: Milli Eğitim Basımevi. 35-40.

Austin, S., Wadlington, E., & Bitner, J. (1992). Effect of beliefs about mathematics on math anxiety and math self-concept in elementary teachers, *Education, 112* (3), 390-396.

Baydar, C.S. (2000). Beliefs *of pre- service mathematics teachers at the Middle East Technical University and the Gazi University about the nature of mathematics and the teaching of mathematics.* Unpublished master's thesis. Middle East Technical University. Ankara.

Carter, G., & Norwood, K. S. (1997). The relationship between teacher and student beliefs about mathematics, School Science and Mathematics, 97 (2), 62-67.

Cobb, P. (1986). Contexts, goals, beliefs and learning mathematics. *For the Learning of Mathematics, 6,* (June 1986), 2-9.

Doan, C.F., Wigfield, A., Eccless, J.S., Blumenfeld, P., Arbreton, A., & Harold, R. D. (2000). "What am I best at? Grade and gender differences in children's beliefs about ability improvement", *Journal of Applied Developmental Psychology, 21* (4), 379-402.

Eccless, J., Wigfield, A., Harold, R.D., & Blumenfelds, P. (1993). Age and gender differences in children's self and task percep-tions during elementary school. *Child Development, 64,* 830-847.

Fennema, E., Peterson, P. L., Carpenter, T.P. & Lubinski C.A. (1990). Teacher's attribution and beliefs about girls, boys, and mathematics. *Educational Studies in Mathematics, 21,* 55-69.

Fleener, M. J. (1996). Scientific world building on the edge of chaos: High school students' beliefs about mathematics and science. *School Science and Mathematics, 6,* 312-324.

Frank, M. L. (1990). What myths about mathematics are held and conveyed by teachers. *Arithmetic Teacher, January,* 10-12.

Garofalo, J. (1989). Beliefs and their influence on mathematical performance. *Mathematics Teacher,* October 1989, 502-505.

Johnson, G. (1981). *An investigation of selected variables and their effect upon the attitude toward the teaching of elementary school mathematics by prospective elementary school teachers.* Paper presented at the Southwest Educational Research (ERIC Document Reproduction Service N0. ED 199 222).

Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D.A. Grows (ed.), *Handbook of research on mathematics teaching and learning,* pp.627-633, New York: McMillan Publishing Company.

McLeod, D. B. (1988). Affective issues in mathematical problem solving: Some theoretical Considerations. *Journal for Research in Mathematics Education, 19,* 134-141.

McClendon, C., & Wigfield, A. (1998). Group differences in African American adolescents' achievement-related beliefs about math and science: An initial study. *Journal of Black Psychology, 24* (1), 28-42.

Midgley, C., Feldlaufer, H., & Eccles, J. (1989). Change in teacher efficacy and student self- and task- related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology, 81* (2), 247-258.

Pajares, F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62* (3), 307-332.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86* (2), 193-203.

Schoenfeld, A. H. (1985). *Mathematical problem solving.* San Diego, CA: Academic Press.

Stipek, D. J., & Gralinski, J. H. (1991). Gender differences in children's achievement-related beliefs and emotional responses to success and failure in mathematics. *Journal of Educational Psychology,* 83 (3), 361-371.

Underhill, R. G. (1988). Focus on research into practice in diagnostic and prescriptive Mathematics. *Focus on Learning Problem in Mathematics, 10* (3), 43-58.

Vanayan, M., White, N., Yuen, P., & Teper, M. (1997). Beliefs and attitudes toward mathematics students: A descriptive study. *School Science and Mathematics, 97* (7), 345-351.

Geliş	8 Haziran 2001
İnceleme	14 Haziran 2001
Kabul	15 Kasım 2001