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Development of mathematics-related beliefs scale for the 5th grade students in Turkey

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The aim of this study was to develop a valid and reliable scale for 5th grade students in Turkey to investigate their mathematics-related beliefs. For this purpose, a mathematics-related belief scale was constructed by the researchers based on Op't Eynde, De Corte and Verschaffel (2003) framework and piloted by 390 5th grade students from 2 middle schools in Ankara, Turkey. Data were analysed by descriptive and inferential statistics. Factor analysis revealed three factors: beliefs about mathematics and mathematics learning, self-efficacy beliefs, and beliefs about the role of the teacher. The overall reliability of the scale was .77, indicating a good reliability. The mathematics-related belief scale will be used in a future study where 5th grade students' mathematics related beliefs will be identified.

Keywords: Scale development, mathematics-related beliefs, 5th grade students.

INTRODUCTION

Beliefs are important components of mathematics teaching and learning process (Kloosterman, 1996; Philipp, 2007). Students' beliefs about mathematics influence the effort they will spend for the tasks, their interest in mathematics, and enjoyment with the task (Kloosterman, 2003), and they have the potential to determine how students connect real life activities and school mathematics (Lester Jr., 2002). Their beliefs about achievement have a considerable influence on their success at school (Wittrock, 1986). Students' learning experiences affect their beliefs and their beliefs about learning influence their approach to the new learning experiences (Spangler, 1992). Therefore, there seems to be a reciprocal relationship between mathematics learning and mathematics related beliefs (Schommer-Aikins, Duell, & Hutter, 2005).

Beliefs are formed by students' direct or indirect experiences (Lester Jr., 2003), which makes their classroom experiences important. However, in order to help students form beliefs which will enhance their mathematics learning, it is substantial to identify their existing beliefs. Identifying younger students' beliefs is specifically important because they are more open to be influenced by classroom experiences.

As a result of the recent change in school system in Turkey 5th grade is included in middle schools with some revision in mathematics curriculum. This revision did not change the emphasis on problem solving and building relationships in middle school mathematics and teachers' facilitating and guiding role for students' learning (MEB, 2013) that the previous curriculum stated. However, to what extent these emphases have influenced students' beliefs at this level has not been investigated yet. Investigating 5th grade students' beliefs when they start middle school will enable us to (i) understand the effectiveness of the elementary school mathematics instruction on students' mathematics related beliefs and (ii) determine the possible mathematical experiences in middle school grades which will help them learn meaningful mathematics. Therefore, the current study aimed to construct a valid and reliable instrument to investigate 5th grade students' mathematics-related beliefs.

There are several scales addressing students' mathematics-related beliefs. However, the psychometric properties of these scales, including some popular scales, are problematic (Walker-Wheeler, 2007) and their Turkish versions either lack validity evidences or target older students' beliefs. Therefore, there is a need to for a valid and reliable scale addressing younger students' mathematics related beliefs.

LITERATURE REVIEW

Several researchers have defined beliefs. For example, Fishbern and Ajzen (1975) define beliefs as information that a person has about an object or idea. According to Richardson (1996), beliefs are "psychologically held understandings, premises, or propositions about the world that are felt to be true" (p. 2). Kloosterman, Raymond and Emenaker (1996, p. 39) refer beliefs as "the personal assumptions from which individuals make decisions about the actions they will undertake." Schoenfeld (1998) indicates that "beliefs are mental constructs that represents the codification of people's experiences and understandings" (p. 21). These definitions address that we have beliefs about the world around us and we also use these beliefs to make sense of the world.

As beliefs are subject specific (Philipp, 2007), there is also a need to define mathematics-related beliefs. There are several definitions of mathematics-related beliefs and there hasn't been an agreement on a common definition (Furinghetti & Pehkonen, 2002). This study employed the definition proposed by Op't Eynde, De Corte and Verschaffel (2003) which addresses mathematics-related beliefs as "the implicitly or explicitly held subjective conceptions students hold to be true, that influence their mathematical learning and problem solving" (p. 28) because it focuses more on students' mathematical learning and problem solving.

Theoretical framework

Different approaches to mathematics-related beliefs have been discussed in the field and several researchers have introduced different categorizations, with common and distinct aspects (Philipp, 2007). A comprehensive framework given by Op't Eynde and colleagues(2003) is mainly based on Schoenfeld's (1983) view that cognitive actions are determined by the nature of the task, social environment, and the perception of the individual. Hence, beliefs reflect the effects of self, belief object and the context (Schoenfeld, 1983). Op't Eynde and colleagues (2003) proposed that mathematics-related beliefs were determined by the context, personal needs, and mathematics education. Their framework had three main categories of beliefs about: (i) mathematics education, (ii) the self, and (iii) social context. This framework was employed for the current study.

Beliefs about mathematics consisted categories of beliefs about mathematics as a subject, mathematics learning and problem solving, and mathematics teaching. Beliefs about mathematics were about the answer of the question "What is mathematics?" in students' minds. Beliefs about self included students' motivational beliefs such as self-efficacy, control, task value, and goal orientation beliefs. Beliefs about social context consisted of beliefs about social norms in students' classrooms including role and the functioning of the teacher and student; and beliefs about socio-mathematical norms such as beliefs about what is accepted as mathematical justification in the class (Cobb & Yackel, 2014). Table 1 summarizes the framework.

This framework is more comprehensive and it contains other classifications which provide a wider perspective for investigating students' beliefs. Therefore, it was employed as the theoretical framework in this study. However, its comprehensive nature makes it difficult to investigate these beliefs a single study with 5th grade students. Therefore, beliefs about nature of mathematics, learning mathematics, role of the teacher, and self-efficacy beliefs were investigated in this study.

SCALE DEVELOPMENT PROCESS

The scale was developed in three main steps. First, the related literature was reviewed in detail and items

Beliefs about mathematics education	Beliefs about self	Beliefs about the social context
-Beliefs about mathematics as a subjects -Beliefs about mathematical learning and problem solving -Beliefs about mathematics teaching in general	-Self-efficacy beliefs -Control beliefs -Task value beliefs -Goal-orientation beliefs	-Beliefs about social norms in their own class The role and functioning of the teacher The role and functioning of the students -Beliefs about socio-mathematical norms in their own class

Table 1: The framework of students' mathematic related beliefs

were written. Then, experts' opinions were gathered and items were revised. Last, five students were interviewed in order to ensure the clarity of the items for the students.

Literature review

An extensive literature review of belief frameworks in the literature were conducted and a comprehensive belief structure framework suggested by Op't Eynde and colleagues (2003) was employed for the study. A detailed examination of this framework, previous studies, and the characteristics of the age group resulted in four sub-domains (factors) to be considered for the study: beliefs about mathematics as subject, beliefs about learning and problem solving, mathematics self-efficacy beliefs, and beliefs about teacher role and functioning. Then, an extensive literature review was conducted for each factor. In general, these factors were studied individually in many studies through several scales in order to understand the types of items which explained the specific belief domain. An examination of these items showed that there were both common and different aspects, and these aspects were taken into consideration to get a more comprehensive instrument. After these studies, the first version of the instrument was developed with 68 items.

Experts' opinion

The first version of the scale was shared by two researchers working on beliefs in the field of mathematics education to examine the content and comprehensibility of the items. They were asked whether the items and factors were coherent, statements were clear, and expressions were appropriate for the 5th grade students. After they reviewed and suggested changes in the items, revised items were shared by two specialists in the field of educational measurement to ensure the properness of the scale in terms of measurement principles. Then, two middle school mathematics teachers reviewed the items with respect to clarity for students as they had more interaction with the students and they suggested certain changes about wording of the items. At the end of the experts' revision, scale consisted of 32 items.

Student interviews

After the revision of the scale, five 5th grade students from a public school in Ankara were interviewed about clarity of the statements. They were asked about what they understood of each item and whether there were any words that they did not know about their meanings. Students had difficulties in three items. It appeared that they considered "lecturing" and "guiding" the same. Therefore, the item "Our teachers guide us when we are learning" was deleted. Students also struggled with the item related to the relationship construction between old and new knowledge. While some students were able to understand the meaning of building relationship, others couldn't understand the item and preferred to respond as undecided. This item was revised as "I remember previous knowledge when I am learning new things" in order to make the statement clear.

In order to ensure that one class hour will be sufficient to complete the scale for students, the time students spent in answering items was observed. Students finished responding 32 items in approximately 20 minutes during the interviews. After the items were reviewed once more with respect to the interview results, the fourth version of the questionnaire was constructed which consisted of 34 items with 3 point Likert scale as agree (3 points), undecided (2 points), and disagree (1 points). Negative items were scored reverse. The maximum score one can get from the scale was 102 and the minimum score was 34. Three-point scale was preferred because 4th and 5th grade students might have difficulty in understanding "partially agree" or "partially disagree" phrases.

DATA COLLECTION AND ANALYSIS

Data for this pilot study were collected from two conveniently selected public middle schools in Ankara. Although there are different suggestions about the sample size for getting proper factor analysis results, it is indicated that larger sample sizes produce more proper results. Tabachnick and Fidell (2007) argue that sample size should be 10 times of the item number or at least 300 for proper factor analysis. These suggestions were taken into consideration and data were collected from 390 students (201 male, 182 female) from fifteen 5th grade (ages 9–10) classrooms.

The implementation was conducted by the first researcher. Before distributing the scale, she explained students that there were no correct answers for the items and their thoughts were important for the research. Students were also informed that no information would be shared with their teachers, their answers would not affect their grades, and there was

no need for writing their names. Data were collected in courses other than mathematics in order to reduce the teacher effect.

Principal Component Analysis (PCA) was conducted in order to determine subscales and validity of the scale. As the sample size was ensured during the data collection, other preparations were performed before conducting PCA. First, negative items were scored reverse. Second, Bartlett Sphericity Test and Kaiser-Meyer-Olkin (KMO) were checked to ensure that data set was factorable which means that some correlations should exist (Tabachnick & Fidell, 2007). In order data set to be appropriate for factor analysis, Bartlett Sphericity Test should be significant, which means p value smaller than 0.05 and KMO value should be at least 0.6 (Tabachnick & Fidell, 2007). The analysis indicated that data set was appropriate for factor analysis ($F=0.80$, $p < 0.05$).

Certain principles suggested by Tabachnick and Fidell (2007) guided the PCA: Items should have factor loadings 0.3 or above to fit the factor structure in the selection process. If items which are loaded in more than one factor have difference between factor loadings smaller than 0.1, then it is better to exclude them from the scale. When deciding the number of factors, the factors with eigenvalues more than 1 are initially taken into consideration. However, only eigenvalues may not be sufficient for the final decision. Another estimate can be made by interpreting scree plot but there is still need for more operations for proper factor solution. Based on these criteria, the factor analysis was repeated until reaching a proper factor solution.

RESULTS

The results of the first analysis showed that there were 11 factors whose eigenvalues were more than 1. However, the scree plot seemed very complicated to reduce the factors and factor loadings were not appropriate. In order to get a more appropriate factor solution, items with communalities less than 0.2 were removed because small communalities indicated that the variable was not related to the other variables in the data set (Tabachnick & Fidell, 2007). Therefore, 11 items were removed from the analysis. In order to reach the best factor solution, the Promax rotation method, an oblique rotation, was employed because gives better results in identifying the correlating and noncorrelating factors (Tabachnick & Fidell, 2007). After this reduction, the analysis was conducted once more and the most appropriate factor solution appeared as 3 factors solution. The scree plot in Figure 1 also supported 3 factors solution. Then, items which were loaded on unrelated factor, items whose factor loadings were smaller than 0.3, and items which were loaded almost equally to more than one factor were removed from the scale.

After deciding the factor structure, 5 items which were indicated as important in the literature were added one by one as they didn't conflict with the factor structure. Two items whose factor loadings were smaller than 0.3 were also added to the scale with the same reason. Wordings of two items were changed

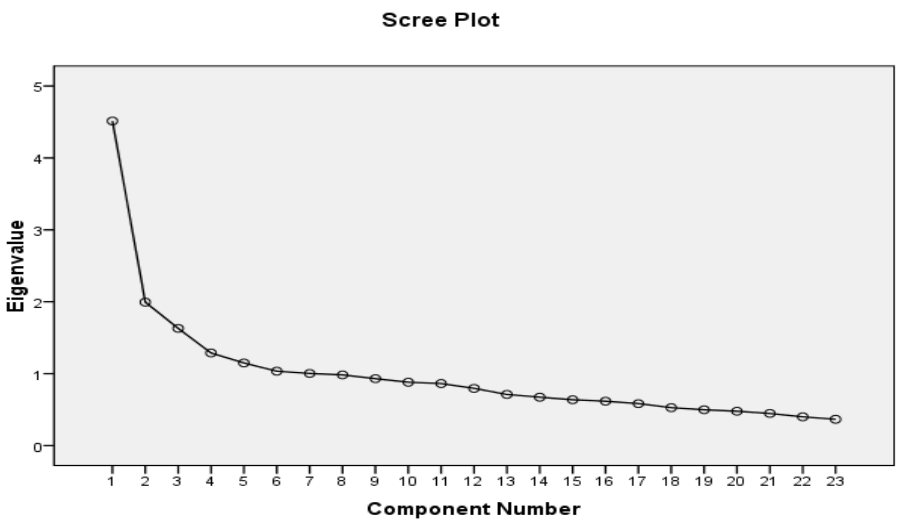

Figure 1: Scree plots of eigenvalues of pilot version of the scale

because they might be confusing for the 5th grade students.

According to the results of the analysis, 6 items were loaded under the first component (*beliefs about teacher's role*), 7 were loaded under the second component (*self-efficacy beliefs*), and 10 were loaded under the third component (*beliefs about mathematics and learning mathematics*). This structure explained the 35% of the total variance in the dependent variable, the total score gained from the scale. The mean and standard deviation of each item are given in Table 2.

Cronbach Alfa coefficient, was computed for the reliability measure and the pilot study of the scale resulted in 0.77 Cronbach Alpha reliability coefficient, which indicated a satisfactory reliable measure (Tabachnick & Fidell, 2007). The Cronbach Alpha value for components of *teacher's role* was 0.48, *self-efficacy* was 0.73, and *mathematics and mathematics learning* was 0.6. Students' mathematics-related beliefs were examined for each component and item by item.

The mean score for *beliefs about teacher's role* component was 14.3 (out of 18). This factor was about how students perceived the role of their mathematics teacher in the class. They rather portrayed their mathematics teachers as the authority for knowledge in the class showing them how to solve problems step-by-step and transferring knowledge to them. On the other hand, they believed that their teachers listened to them carefully and made mathematics lessons fun. Their teachers also seemed somewhat to encourage them to discuss mathematics problems.

Students' mean score in *self-efficacy* component was somewhere between undecided and agree (x=16.7 out of 21). They seemed to believe that they had ability in mathematics. They felt confident while studying mathematics and mathematics was not a difficult

Items	Mean	SD
Teacher is the one who transfers knowledge to us.*	1.07	.340
Teacher shows us how to solve mathematics problems step by step.*	1.10	.376
Our teacher enables us to discuss mathematics problems with our classmates.	2.32	.806
Our teacher behaves us friendly.	2.77	.559
Our teacher teaches mathematics lessons in fun way.	2.68	.630
When we ask questions, our teacher listens to us carefully.	2.85	.450
When we don't understand a mathematics concept for the first time, we cannot understand it later.*	2.18	.885
Mathematics is a difficult subject for me.*	2.39	.778
I think I don't have ability in mathematics.*	2.46	.740
I can make mathematics homework easily.	2.70	.536
While studying mathematics, I feel that my self-confidence is decreasing.*	2.53	.747
Mathematics is easy for me to understand.	2.48	.690
I panic when I come across a different mathematics problem.*	2.05	.865
Mathematics concepts are related to each other.	2.58	.666
We use school mathematics concepts in our daily life.	2.86	.417
Knowing mathematics makes our life easier.	2.86	.449
Mathematics homework helps me understand mathematics better.	2.78	.536
Studying mathematics increases our mathematics ability.	2.82	.467
Making mistakes in mathematics helps in learning.	2.16	.856
Understanding is important while learning mathematics.	2.90	.383
There may be more than one solution path for mathematics problems.	2.86	.430
While learning mathematics, I need to remember my previous knowledge.	2.71	.604
Mathematics problems can be solved correctly only by our teachers' solution methods.*+	1.99	.887
It is important to develop different solutions while solving a mathematics problem.	2.74	.537

* indicates negative items. All items are translated by the authors.

+ This item was added to the final scale although it did not appear in this factor.

Table 2: Descriptive statistics of each item

subject for them. However, students were undecided about whether they could understand a concept which they couldn't understand in the first time later and that they would panic when they see a mathematics problem for the first time.

Students' mean score in *mathematics and mathematics learning* component was 27.3 (out of 33). Students agreed that knowing mathematics will ease their life and school mathematics could be used in real life. Their responses indicated that they considered mathematical concepts as related to each other, rather than unrelated facts. They agreed that there might be more than one solution for a mathematics problem and it was important to develop these solutions, but they were undecided for whether problems could be solved only by their teachers' method. Students believed that studying mathematics and working on homework enhanced their mathematics learning but they were undecided about the role of making mistakes in their learning.

DISCUSSION

The main purpose of this study was to develop a valid and reliable scale. The results showed that although the scale was constructed in four sub-domains, the items related to beliefs about nature of mathematics and beliefs about mathematics learning were loaded under the same factor. It might be the case that students' beliefs about learning mathematics are closely related to what they believe mathematics is about. *Self-efficacy* items and items related to *teacher role* appeared in separate factors as designed. The overall reliability of the scale was high, but *teacher's role* factor had lower reliability measure. The reason might be related to the number of items. Cronbach's Alpha value is very sensitive to number of items and when it is fewer than ten, it may take lower values (Tabachnick & Fidell, 2007).

Students' responses indicated that they agreed with rather authoritarian teacher roles in the classroom, but their classroom experiences seemed to help them develop beliefs about the connected nature of mathematical knowledge and existence of multiple solutions for mathematical problems. They also believed in the usefulness of mathematics, a belief that elementary school students tended to develop as they progressed towards higher grades (Kloosterman, Raymond, & Emenaker, 1996). Students' responses indicated that their teachers might be supporting discussion in the mathematics classroom, although the nature of the discussion was unknown. When students believed that they could learn mathematics through discussion, they engaged in discussion in the mathematics class (Jansen, 2008). These findings addressed that guiding mathematics teachers for effective discussion in the classroom could be considered in order to help students develop beliefs about and practice effective discussion in the middle school mathematics classrooms.

Students seemed to believe that spending effort in mathematics resulted in learning. Fifth grade students might not have developed beliefs about quick learning which relates learning quickly to ability rather than hard work. This might have resulted in their beliefs about the usefulness of mathematics, as observed in 7th and 8th grades students in other contexts (Schommer-Aikins, Duell, & Hutter, 2005).

Fifth grade students in this study had considerably higher self-efficacy beliefs and mathematics was not a difficult subject for them. These findings addressed that there might be a promising cumulative influence of elementary school and 5th grade experiences the mathematics class on students' beliefs. Understanding the nature of these experiences could provide middle and high school mathematics teachers with ideas for their practices resulting in higher efficacy beliefs in students.

REFERENCES

Cobb, P., & Yackel, E. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*, 458–477.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Furinghetti, F., & Pehkonen, E. (2002). Rethinking characterizations of beliefs. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 39–58). Dordrecht: Kluwer Academic Publishers.

Jansen, A. (2008). An investigation of relationship between seventh-grade students' beliefs and their participation during mathematics discussions in two classrooms. *Mathematical Thinking and Learning, 10*, 68–100. doi: 10.1080/10986060701820327

Kloosterman, P. (1996). Students' beliefs about knowing and learning mathematics: Implications for motivation. In M.

Carr (Ed.), *Motivation in mathematics* (pp. 131–156). New Jersey, NJ: Hampton Press.

Kloosterman, P., Raymond, A. M., & Emenaker, C. (1996). Students' beliefs about mathematics: A three-year study. *The Elementary School Journal, 97*, 39–56.

Kloosterman, P. (2003). Beliefs and motivation. In G.C. Leder, E.Pehkonen, & G.Törner (Eds.), *Beliefs: A hidden variable in mathematics education*? (pp. 247–269). Dordrecht: Kluwer Academic Publishers.

Lester Jr., F. (2003). Implications of research on students' beliefs. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 342–353). Dordrecht: Kluwer Academic Publishers.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics* (pp. 575–596). New York, N.Y: Macmillan.

Milli Eğitim Bakanlığı [MEB]. (2013). *Ortaokul matematik dersi (5, 6, 7 ve 8. sınıflar) öğretim programı*. Ankara: Milli Eğitim Bakanlığı.

Op't Eynde, P., De Corte, E., & Verschaffel, L. (2003). Framing students' mathematics-related beliefs. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 39–57). Dordrecht: Kluwer Academic Publishers.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 257–315). United States: Information Age Publishing.

Schommer-Aikins, M., Duell, O., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving beliefs, and academic performance of middle school students. *The Elementary School Journal, 105*, 289–304. doi: 10.1086/428745

Schonfeld, A. H (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognition as driving forces in intellectual performance. *Cognitive Science, 7*, 329–363.

Schoenfeld. A. H. (1998). Towards a theory of teaching in context. *Issues in Education, 4*, 1–94. doi:10.1016/S1080-9724(99)80076-7

Spangler, D. A. (1992). Assessing students' beliefs about mathematics. *The Mathematics Educator, 3*, 19–23

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston: Pearson Education.

Walker-Wheeler, D. N. (2007). *The development and construct validation of epistemological beliefs' survey for mathematics*. (Unpublished doctoral dissertation). Oklahoma State University.

Wittrock, M. C. (1986). Students' thought processes. In M. C. Wittrock (Ed.), *Handbook of research in teaching* (pp. 297–314). New York: Macmillian.