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Adaptation of mathematical processing instrument into Turkish

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Abstract

Thinking styles of students in problem solving environments is an important theme for mathematics education researches. Specifically, to determine students' preferences in mathematical problem solving situations give teachers clues about learning practices of students which are important for effective course plans, classroom activities and tasks. The aim of this study is to evaluate the validity and reliability of Mathematical Processing Instrument (MPI) which was developed by Norma Presmeg (1985) in the USA for Turkey's education conditions. As a part of the study, section B -developed especially for teachers of mathematics at high school - is translated into Turkish; and its validity and reliability is evaluated.

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Keywords: Mathematics education; visual preference; Mathematical Processing Instrument; problem solving; preservice teachers.

1. Introduction

Thinking styles of the students in problem solving environments is an important theme for the researchers in the mathematics education area. Particularly students' preferences in problem solving environments give ideas for teachers to establish effective course plans, classroom activities and tasks. In this context, visualization has been considered as a way of reasoning in mathematics research as well as in mathematics learning (Borba & Villarreal, 2005). In previous researches students were classified according to these reasoning styles and different frameworks were used for this classification by different researchers (Krutetskii, 1976; Clements, 1982; Presmeg 1985). Moreover, not only students, but also mathematicians offered evidence for different thinking styles (Burton & Sinclair, 2004)

Classification of individuals in this way had been accepted in the previous researches. However; since the problem solving process is a specific situation which varies according to the problem to be solved and to every individual, the idea was not considered as useful lateron. Thus the term "types of processing" is preferred rather than "types of individuals" (Aspinwal, Shaw & Presmeg, 1997). According to the later classification, Presmeg (1986, cit. Russel, 1997) defined visualizers as "...individuals who prefer to use visual methods when attempting mathematical

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problems which may be solved by both visual and nonvisual methods” analogously, non-visualizers as “...individuals who prefer not to use visual methods when attempting...[mathematical problems which may be solved by both visual and non-visual methods]” (p. 298).

Considering the educational goals in mathematics classrooms, teachers are the ones who are responsible for the learning of the students. Using only one or limited amount of teaching methods for all concepts in the curriculum means ignoring the learning process of the students whose learning styles are different than the teaching style of the teacher. For instance, a very detailed verbal explanation may have been enough for the students who have auditory learning preferences but on the other hand, a graphical or pictorial form of solution to a mathematical problem could aid the understanding of a visual learner (Russel, 1997). It is most likely that all teachers have developed their own preferences for problem solving, so they may impose these preferences to students in their classrooms consciously or unconsciously. In a research conducted by Presmeg (1991, cit. Presmeg, 2006) teaching visuality of mathematics teachers’ whose preferences vary from highly visual to highly non-visual and its effect on visual students in their classrooms were determined. In the class of teachers whose teaching visuality is non-visual, the students with visual tendency had to quit their preferences as a result of the teaching style of the instructor. Thus, the success level among these students dropped drastically. Similarly, highly visual teachers often did not realize the difficulties some students had with a visual approach. On the other hand the students in the class of middle group teachers (according their teaching visuality score) received more support to overcome their generalization problems, when they are allowed to use their preferred mode of mathematical processing by their teachers. So the visualizers were the most successful group in the research. The outcome of the research is also parallel with the findings of the study conducted by Zaskis, Dubinsky and Deutermann (1996). According to them visualizer/analyzer may not be an appropriate classification scheme for describing the learning processes or for designing the needed instruction. They suggest that visualization and analysis are two modes of thinking that are interacting and supporting each other.

Mathematical Processing Instrument (MPI), developed by Presmeg (1985), is a two staged instrument to measure students and teacher’s preferences for visual methods in solving non-routine mathematical problems. First part consists of three sections (A, 6 problems; B, 12 problems and C, 6 problems). Section A and Section B are designed for students in high school. Section B and Section C are for teachers of mathematics at high school. The problems in different sections have changing level of difficulty.

Second part consists of possible solutions of the problems in the first part offering different methods.

One of these problems in MPI and its possible solution methods are as follows:

Problem 9 in Section B:

B-9. A passenger who had traveled half his journey fell asleep. When he awoke, he still had to travel half the distance that he had traveled while sleeping. For what part of the entire journey had he been asleep?

Second Part for Problem 9 in Section B:

B-9. Solution 1: I drew a diagram representing the distance traveled.



Half his journey Distance he slept Half distance he traveled while sleeping

From the diagram, if the whole journey is 6 parts, he slept for 2 parts, that is, one third of the entire journey.

B-9. Solution 2: As in solution 1, but I “saw” the diagram in my mind.

B-9. Solution 3: I solved this problem using symbols and equations, e.g.

Let the distance for which he slept be x units.

When he awoke, the remaining distance was $\frac{1}{2}x$ units.

Then $(x + \frac{1}{2}x)$ constitutes half the journey.

So the whole journey was $2(x + \frac{1}{2}x) = 3x$ units.

Thus he slept for one third of the journey.

B-9. Solution 4: None of them

The aim of this study is to evaluate the validity and reliability of Mathematical Processing Instrument (Section B) for Turkey's conditions.

2. Method

2.1. Adaptation of MPI into Turkish

The adaptation process started after the authorization is get from Norma Presmeg who developed the instrument to use MPI. The original form of MPI was prepared in English. At the beginning of the study Section B of MPI (will be abbreviated as MPI-SB in the rest of the paper) that used in this study was translated into Turkish by the researchers. Afterwards this translation was checked by two language experts and a mathematician who also knows English language. In accordance with the opinions of the experts, final version of MPI is formulated. First application of MPI-SB was made with 20 students in a mathematics teacher training program and got feedback from students to make the last revisions about the latest form of MPI-SB.

In the application process of MPI-SB students were asked to show their working as much as possible for each problem and to attempt all problems. Secondly, the second part of MPI for section B was given to the students to check the most similar solution to theirs.

The solutions in the questionnaire were scored according to their visuality. 2 points for visual solutions, 0 point for non-visual solutions and 1 point if it is not attempted or unclear. Thus the maximum score for visual preference for the section B equals 24. The visualizes are the scored above the median score of the participants. In this questionnaire there is also an alternative "none of them" option for the students whose solutions are not similar with the alternatives or are not involved in the questionnaire. These kinds of responses were evaluated by the researchers whether the solution is visual or non-visual through considering the working of the students.

2.2. Reliability and validity

When the instrument was first developed, split-half reliability was used. The outcome yielded a correlation of about 0.96, which suggested that the test was reliable. However, in this study test-retest reliability was used. The analysis of the data was conducted using the SPSS 13.0 software program.

For the reliability analysis, MPI-SB was administered by 50 students (20 boys and 30 girls) in a mathematics teaching training program during the 2008-2009 fall semester with 19-day interval.

For the construct validity clinical interviews were conducted with 10 students (5 visualizer and 5 non-visualizer) from this group. The videotaped interview consisted of 4 problems from Integral concept. The problems could be solved using both visual and non-visual methods as well. Solving the problems, the students were asked to describe their thinking. Based on their words and written works, an estimated visualization score was assigned them. Spearman's rho correlation was used to compare their scores on the interview with the ones on the MPI-SB.

3. Results

The frequency distribution of scores was checked before correlation analysis. Regarding to Kolmogorov-Smirnov Test, students' scores in both applications follow a normal distribution ($p_{first} = .101$, $p_{last} = .287$). The fact that previous studies have also found that MPI scores are normally distributed was indicated by Galindo-Morales (1994). As a result, the finding corresponds to other researches' findings. Besides that the relationship between the two measurements' scores are linear.

The test-retest correlation coefficient was calculated for testing reliability. The Pearson Correlation Coefficient between the two applications was found significant at $r = .803$ (Table 1).

Table 1. Correlations

		B1Total	B2Total
B1Total	Pearson correlation	1,000	,803**
	Sig. (2-tailed)	.	,000
	N	50	50
B2Total	Pearson correlation	,803**	1,000
	Sig. (2-tailed)	,000	.
	N	50	50

*. Correlation is significant at the 0.01 level (2-tailed)

For construct validity Spearman's rho correlation was used to compare the scores on the interview and on the MPI-SB. The correlation coefficient is $r = .713$ (Table 2) which can be judged to be sufficient.

Table 2. Nonparametric Correlations

		Total B	Interview
Spearman's rho	Total B	Correlation Coefficient	,713*
		Sig. (2-tailed)	,021
		N	10
	Interview	Correlation Coefficient	,713*
		Sig. (2-tailed)	,021
		N	10

*. Correlation is significant at the 0.05 level (2-tailed)

4. Discussion and Conclusion

In reference to the distribution of scores gathered from MPI, number of visualizers is as much as the non-visualizers. This information is an important fact not to be ignored by the people working in the mathematics education area. Moreover the visualization has an important role in the learning process. Arcavi (2003) states that visualization is (a) a support and an illustration of essentially symbolic results (and possibly providing a proof in its own right) (b) a possible way of resolving conflict between (correct) symbolic solutions and (incorrect) intuitions, and (c) a way to help us re-engage with and recover conceptual underpinnings which may be easily bypassed by formal solutions. However, students are often reluctant to visualize (Eisenberg & Dreyfus, 1991) and prefer analytical solutions. According to Presmeg (1999) it is a learned phenomenon. Students mostly tend to adopt their teachers' preferences or the teachers impose their ways consciously or unconsciously. However, to know the preferences of students in a learning environment may help teachers to adapt the learning activities for all the students with different thinking styles- not just for visualizers or not just non-visualizers-.

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