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Mathematics motivation scale: a validity and reliability

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Abstract

Researches related to motivation and mathematics achievement indicate that academic intrinsic math motivation is related to mathematics achievement (Yıldırım, 2011; Gottfried, et al, 2007). For this reason there is need for a scale to measure the motivation related to mathematics achievement. During the scale carrying out process, less-known but more effective validated procedures are used. The aim of this study is carrying out a reliability and validity study for a scale which assess the moti vation related to mathematics achievement. In this research, the scale is applied to 6th, 7th, 8th grade students, the data obtained is analyzed for the validity and reliability studies of the scale. However the most frequently used statistical methods are eigenvalues-greater-than-one-rule and scree plot, Velicer's Map Test (1986) and Parallel analysis are used as less-known validated procedures in structural validation studies (O'Connor, 2000). In addition to those less-known validation procedures, confirmatory factor analysis is used to compare the results of validation procedures. Results show that the reliability of this scale is satisfying. Moreover, the findings of confirmatory factor analysis are similar to the findings of less-known validation procedures determined below. As a result of this research the validity and reliability value of the scale are provided. Findings show that the less-known validation procedures give stronger statistical results than the popular analyses procedures given below. That's why those validation procedures should be used for the development of this kind of scales.

Keywords: mathematics motivation, motivation orientation scales, Velicer's map test, parallel analysis

1. Introduction

1.1. Problem Statement

Introducing the factors affecting the academic performance determines the quality of education system (Alnabhan, Al-Zegoul ve Harwell, 2001). Motivation is one of the most important factors in this sense. It means that, motivation is accepted as an important element of students' academic achievements (Freedman, 1997; Lee & Brophy, 1996). Motivation is accepted as a tool affects the creativity of students, learning styles and academic achievements (Kuyper, van der Werf & Lubbers, 2000; Wolters, 1999). That's why it can be said that if the motivation is ignored, teaching will be ineffective. Especially in elementary years, since the motivation factor is so important, Cavallo (2002) expressed that teachers must plan the lessons with attractive activities in order to get the students' attention. Like other disciplines, motivation has a big effect on mathematics lessons. Moreover, since

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motivation guides students, it can help students to predict the procedure and the result of mathematical activities. The motivation term can be divided into two parts as intrinsic motivation and extrinsic motivation. According to Deci and Ryan (1985), intrinsic motivation fosters engagement and it is the result of the needs for competence, autonomy, and relatedness. In addition to that it is the purpose of performing a behavior is for the pleasure and satisfaction of the process and associated with feelings of control (Biddle and Mutrie, 2001). On the other hand, extrinsic motivation can be defined as the purpose of a behavior is to gain benefits or avoid negative consequences that are expected to occur afterwards that promotes behavior through contingent outcomes that lie outside the activity. If the students' behaviors about their motivation are analyzed it can be seen that if the children are intrinsically motivated, then they believe to work to promote creative responses that are focused on the task. Otherwise if the children are motivated externally, then they are not contingent on the presence of external reinforces.

According to the researches done, there are independent dimensions of success related to motivation term (Nicholls, Cheung, Lauer, & Patashnick, 1989; Nicholls, Cobb, Yackel, Wood & Wheatley, 1990). The first dimension is task orientation, second dimension is ego orientation and the third dimension is work avoidance. Duda and Nicholls (1992) expressed that, task orientation is the goal of improving one's skill or gaining insight or knowledge and the beliefs that, in order to be successful, work hard, attempt to understand schoolwork, and collaborate with peers. According to Middleton and Spanias (1999), achievement motivation of children in mathematics, depends on task behavior. The second dimension is the ego orientation. It is defined as the goal of establishing one's superiority over others and the beliefs that success in school requires attempts to beat others and superior ability. McFarland & Ross (1982) and Kukla (1978) indicate that in achievement situations individuals' desire success, indicate high ability and seek to avoid failure to the extent that it indicates low ability. In achievement situations, the individual's purpose is to demonstrate high ability and to avoid demonstrate low ability (Nicholls, 1984). The terms task orientation versus ego orientation are the two perspectives for the achievement motivation (Duda, 1993; Nicholls, 1989) and in addition to that researchers have also proposed that students may be avoidance-oriented in learning situations (Duda & Niholls, 1992). Moreover the factor analyses indicate that task orientation, ego orientation, and avoidance orientation are distinct goal orientation factors (Duda &Nicholls, 1992).

During the task orientation, if students can be motivated intrinsically about the given task, they tend to exhibit a number of pedagogically desirable behaviors including increased time on task, persistence in the face of failure, more elaborative processing and monitoring of comprehension, selection of more difficult tasks, greater creativity and risk taking, selection of deeper and more efficient performance and learning strategies, and choice of an activity (Lepper, 1988). In addition to that, Nicholls (1984) indicated that, if individuals are ego involved, their chances of demonstrating ability depend on the ability of other individuals. The third dimension, work avoidance, entails the goal of not working hard. It is an especially disturbing goal pattern in which working hard is not valued. Also the belief that success is dependent on behaving "nicely" (Butler, 1987; Nicholls, 1975).

2. Purpose of Study

In this sense since there are three important dimensions related to motivation, for this research, with doing adaptations, Motivation Orientation Scales (MOS) (Nicholls et al., 1990; Duda & Nicholls, 1992) is used to measure the factors affects the mathematics motivation. In order to apply this scale, adaptation studies are done and applied to the elementary school students. In this sense, during the adaptation studies, determination of the reliability and validity of the related scale are done. For validity studies, two methods are used to determine the factors of the scale. Those methods are Velicer's MAP Test and Horn's Paralel Analysis with O'Connor's syntax program.

3. Method

In study, the validity and reliability of Nicholl's Motivation Orientation Scale (MOS) application of Turkish students was intended to work. For the adaptation process of related 15 items, these applications are done:

First of all 15 items with the same sentence structure which have the same grammar form and suitable for the aim of this research are chosen. Then with a language expert, Turkish translations of those 15 items are done. After then, two mathematics education experts are also asked to translate those items into Turkish again. After obtaining three translations from three different experts for each item, the most suitable translation was selected by another expert for each item again. After that point, five point scale was formed which was ranging from strongly agree to strongly disagree. The prepared draft form was presented to four field expert and they gave 7.5 point out of 10 to the draft form.

Therefore following procedure was applied, respectively; first the procedure for translation of the MOS was applied, and then MOS was applied to 567 primary students in different grades. For validity analysis Velicer's MAP Test (Minimum average partial methods), Paralel Analysis (with Glorfeld's extension) and Confirmatory factor Analysis were used. Then for reliability of MOS, Cronbach's Alpha Coefficients were analysed for each dimension. Finally all results have been reported.

3.1. Participants and Data Collection

567 participants, who are students in 6th (207), 7^{th} (181) and 8th (179) grades in primary school, have participated in the study voluntarily. 274 of the students were girl and 293 of them were boy. MOS was administered to those groups. It was told that participation was voluntary, scores would be kept anonymous.
For data collection Motivation Orientation Scale was used. The 15 items which have the same sentence structure which have the same grammar form, are modificated in that questionnaire. Items start as *" I feel really pleased in maths when ..."* followed by a statement reflecting either task involvement or work avoidance. Students rated each statement on a five point scale ranging from strongly agree to strongly disagree.

3.2. Data analysis

Velicer's MAP Test, Parallel analysis and Confirmatory factor analysis were used to determine the construct validity of scale. The MAP test and parallel analysis were implemented with the use of available syntax (O'Connor, 2000). For implementation of MAP test, O'Connor's program requires a correlation matrix or principal component analysis of the variables of interest. So first a correlation matrix was prepared and then the matrix was placed into the syntax and the program was executed. For parallel analysis the program do not need correlation matrix and the necessary definition in the program was for our variables (N=567 and k=15). Program was executed for the parallel analysis too. With using of O'Connor's syntax; MAP test and parallel analysis provides number of dimension directly. The number of dimensions which offered on MAP test and parallel analysis; directly visible in the output. We performed a confirmatory factor analysis (CFA) using LISREL 8.80 on the MOS (Joreskog&Sörbon, 2002). The measured and structural model were evaluated with the following index $\chi 2$, the goodness of Fit Index (GFI), the comparative fit index (CFI), the incremental fit index (IFI), normal fit index (NFI) and Parsimony Goodness of fit index (PGFI), and root mean square residuals (RMR), RMSEA, and $\chi 2$/df criterion. Finally for all dimensions Cronbach Alpha coefficient calculated.

4. Findings

The psychometric properties of MOS on Turkish student samples with; MAP test, Parallel analysis, confirmatory factor analysis and Cronbach's Alpha application was given below.

4.1. The Findings of Velicer'MAP Test and Parallel Analysis for construct validity

According to O'Connor (2000), Velicer's (1976) MAP test involves a complete principal components analysis followed by examination of the series of the matrices of partial correlations. Specifically, on the first step, the first principal component is partialled out of the correlations between the variables of interest and the average squared coefficient in the off-diagonals of the resulting partial correlation matrix is computed. On the second step, the first two principal components are partialled out of the original correlation matrix and the average squared partial correlation is again computed. These computations are conducted for k (the number of variables) minus one step is then lined up, and the number of components is determined by the step number in the analyses that resulted in the lowest average squared partial correlation. The average squared coefficient in the original correlation matrix is also computed, and if this coefficient happens to be lower than the lowest average squared partial correlation, then no components should be extracted from the correlation matrix. Statistically, components are retained as long as the variance in the correlation matrix represent systematic variance. Components are no longer retained when there is proportionally more unsystematic variance than systematic variance. Parallel analysis involves extracting eigenvalues from random data sets that parallel the actual data set with regard to the number of cases and variables. For our example, the original data set consist of 567 observations for each of 15 variables, then a series of random data matrices of this size (567 by 15) would be generated, and eigenvalues would be computed for the correlation matrices for the original data and for each of random data sets. The eigenvalues derived from the actual data are then compared to the eigenvalues would be computed for the correlation matrices for the original data and for each of the random data sets. The eigenvalues derived from the actual data are then compared to the eigenvalues derived from the random data. In Horn's (1965) original description of this procedure, the mean eigenvalues from the random data served as the comparison baseline, on the other hand the recommended practice is to use the eigenvalues that correspond to the desired percentile (typically the 95th) of the distribution of random eigenvalues (Glorfeld, 1995; O'Connor, 2000). Factors or components are retained as long as the ith eigenvalue from the actual data is greater than the ith eigenvalue from the random data.

Table 1. MAP Test and Parallel Analysis Results for the Number of Components

No	Actual Eigenvalues	Average partial Correlation		Random Data Eigen Values		No	Actual Eigenvalues	Average partial Correlation		Random data Eigen Values	
		Squared	*Power 4*	*Means*	*%95 Prcntyle*			*Squared*	*Power 4*	*Means*	*%95 Prcntyle*
0	3,1153	0,0431	0,0076	1,281	1,340	**8**	,6369	0,0906	0,0304	0,960	0,985
1	2,2880	0,0296	0,0049	1,219	1,251	**9**	,5927	0,1215	0,0459	0,930	0,958
2	1,8781	0,0370	0,0041	1,173	1,207	**10**	,5473	0,1674	0,0800	0,898	0,926
3	1,1538	**0,0242***	**0,0034****	1,133	1,164	**11**	,5114	0,2429	0,1244	0,867	0,899
4	,9107	0,0301	0,0049	1,093	1,210	**12**	,4806	0,3972	0,2818	0,832	0,869
5	,8143	0,0392	0,0078	1,060	1,090	**13**	,4273	0,6055	0,5398	0,793	0,829
6	,7008	0,0523	0,0126	1,023	1,047	**14**	,2589	1,000	1,0000	0,747	0,788
7	,6836	0,0686	0,0181	0,994	1,020						

**The smallest average squared partial correlation*
*** The smallest 4th power partial correlation*

To further identify the dimensions of the construct measured by the MOS, exploratory analysis on the first sample were conducted using the results from both Horn's parallel analysis (HPA) and Minimum Average Partial (MAP), the procedures which were broadly validated recommended by statisticians (O'Connor, 2000). Both MAP and HPA procedures identified three factors. Table 1 indicates that both the original MAP and the revised MAP suggested the retention three factors. Because the smallest eigenvalue is 0,0242 (squared) and 0,9934 (power 4). Also shows the comparisons of the result of the HPA test with the actual eigenvalues. From table it can be seen that initial three eigenvalues are greater than those generated by HPA (for the both average and the 95 th percentile criteria); as such HPA also discovered three factors.

4.2. The findings of Confirmatory Factor Analysis

The confirmatory factor analysis (CFA) on samples systematically discovered that the hypothesized measurement model of the three dimension construct provided significantly better model fit.

Table 2. Confirmatory Factor Analysis, FIT Indices Results

MOS	n	Chi-square	CFI	NFI	IFI	GFI	PGFI	RMSEA	RMR

		(df)								
Nicholls et al(1989)	567	830,97 (87)	0,69	0,67	0,69	0,84	0,61	0,123	0,11
Our adaptation study (2011)	567	201,23 (86)	0,95	0,92	0,95	0,95	0,68	0,049	0,052

For MOS in Nicholls and his friends provided two basis factor; first motivation and other beliefs about success, there were three sub- dimension (in original four, but then one of them extracted from scale) with motivation: Work Hard, Understand and collaborate and work avoidance, some different researchers had made some modification on the items of the scale in different years. But all validity studies done in other related researches, the motivation factor have three sub-dimensions. So the confirmatory factor analysis was made for original and modifying scale.

Table 2 list of the model fit of three factor model and comparisons of the statistics done. The three factor model produced chi-square statistics with $p<0.05$. RMSEA equals to 0,123. RMR is equal 0,11. The other fit indices including CFI is 0,69; NFI is 0,67; IFI is 0,69 and GFI is 0,84; PGFI is 0,61. Based on those results the model fit index show a bad model fit.

The scale that forms with our adaptation study has fit indices, RMSEA and Chi-square values confirmed three factor structures too. Chi-square statistics with $p<0{,}005$, RMSEA equals 0,049; fit indices are all larger 0,90 too and PGFI indices was equal to 0,59 and RMR is equal 0,052. So these results confirmed three factor structures too.

4.3. Findings about reliability of the MOS

The Cronbach Alpha coefficient was accounted for sub dimension of motivation factor. The values have given at below tables.

Table 3. MAP The Cronbach Alpha Coefficient of Scale

	Work Hard	Understanding and Collaborate	Work Avoidance
Original scale	0,640	0,564	0,680
Modifiying Scale	Task Orientation I (intrinsic motivation) 0,736	Task Orientation II (extrinsic motivation) 0,809	Work Avoidance 0,680

Our adaptation scale has higher reliability values than the original scale as seen in Table 3.

5. Conclusion and Recommendations

For this study, the items of MOS developed by Nicholls and his friends, analyzed and the items related to the three basic factors named work hard, understand and collaborate and work avoidance are studied. The researches related to the MOS are observed and it is seen that, sometimes the items expressed different styles or modificated. But the all studies say that those items are loaded in three dimensions. Also in our study with MAP and Parallel analyses, the items are loaded in three dimensions. According to the dimensions expressed by Nicholls and his friends, the results of confirmatory factor analyses index does not support the three dimensional structure suggestion of the scale. But, with this study with the new dimensions, confirmatory factor analyses index is satisfactory and supports the three dimensional structure. In this study the first factor is Task Orientation I can be named as intrinsic motivation, the second factor is Task Orientation II can be named as extrinsic motivation and the third factor is named as work avoidance like the original scale. The terms intrinsic motivation and extrinsic motivation for the first and second factors is used by the help of views of field area experts. The items with the new factors are given to the mathematics education field area experts and by the help of related literature those terms are suggested for the first two factors.

To sum up for this study, a reliability and validity study is done with different method for an important scale related to the motivation in mathematics.

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