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Procedia - Social and Behavioral Sciences 197 (2015) 851 – 857

Procedia
Social and Behavioral Sciences

7th World Conference on Educational Sciences, (WCES-2015), 05-07 February 2015, Novotel Athens Convention Center, Athens, Greece

Scaling With Paired Comparison Method For Reasons For Mathematics Anxiety Of Secondary School Students

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Abstract

In this study, a paired comparison method, rarely encountered in the literature, was used in order to reveal the reasons for mathematical anxiety of secondary school students. Looking at the coherence among the stimuli created in order to reveal this, we attempted to obtain information about whether the items of the scale harmonized with each other. In the analysis of the data, the scale values were obtained first using case V and then case III. It was found that the item ranges for case III were more consistent compared with those of case V. In conclusion, it can be said that the stimuli identified are differential.

Peer-review under responsibility of Academic World Education and Research Center.

Keywords: Paired Comparison Method, Scaling, Reasons for Mathematical Anxiety

1. Introduction

Many students feel anxious about mathematics thinking that it is difficult and that they will not be successful in it, and develop negative attitudes towards mathematics. Mathematics anxiety appears to exist in students at each grade level (Basar, Unal & Yalcin, 2002), and unfortunately it continues to increase as school years progress (Baykul, 2003, p. 28). This situation causes students to move away from mathematics (Dursun & Dede, 2004)

In general, measurement is "the expression of whether an object or objects possess a particular feature or not and, if so, the observation results with symbols and numeric symbols by observing the degree of possession"(Tekin, 1991, p. 31). Expression of these results in numbers will help to increase the sensitivity. Scaling approaches are used

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Peer-review under responsibility of Academic World Education and Research Center.
doi:10.1016/j.sbspro.2015.07.209

to evaluate whether different stimuli in the same category in the universe have a feature or not (Nartgun, 2006). Scaling represents a very important link in the transition from observations indicating qualitative distinctions to measurements indicating quantitative distinctions in the measurement process (Anıl and Guler, 2006). Scaling is the process of converting a measurement tool to more convenient standard scores. According to Turgut and Baykul (1992), scales are seen as a branch of science that aims to establish basic rules and methods of converting the measurements to observation. With this process; scaling is expressed as revealing the transition process from the relationships based on observations to the relationships based on rules. When we look at the scaling process more theoretically; it can be expressed as the scaling of the tools used to measure the qualities of variables and converting the measurements as a result of measuring variables with unscaled tools into scaled scores (Turgut & Baykul, 1992, p.1; Dunn-Rankin, Knezek, Wallace & Zhang, 2004, p.1).

In addition to scoring; providing information about the dimension of the concepts to be examined (Turgut & Baykul, 1992, p. 11) and about whether the items of a scales are consistent with each other or not are among the objectives of scaling (Torgerson, 1958, p. 100). Nartgun (2006) has interpreted it as utilization of scaling techniques to determine the difference between the levels of stimuli having the measured features and to demonstrate these differences more clearly.

In behavioral science, researchers are in an effort to measure and compare people's perceptions. For this purpose, they try to bring the data both in scale development and that are measured in no-unit classification scale to an equal interval scale level (Acar-Guvendir & Ozer- Ozkan, 2013). After the data obtain, scaling methods of fractionation may benefit some experimental methods. Providing that basic theoretical approach remain same, analytical operations can be change. When the experiment method of paired comparisons combine with the law of comparative judgment, it can be used to determined scale values. (Torgerson, 1958, p. 95). Because under each experimental conditions, experiments reflect individual measurments (Pelli & Farell, 1995, p. 29.2). Similarly, it is said that development of scaling technique began with psychophysics, a sub-branch of experimental psychology (Acar-Guvendir & Ozer- Ozkan, 2013; Kan, 2008). Those dealing with psychophysics examine the relationship between the physical stimuli and the perceptions and feelings it affects (Luce & Krumhansl, 1988, p. 6). Yurdugul (2005) described psychophysics as a space and stated it will be located in this space because of the fact that the studies conducted in education and psychology exhibit an implicit feature.

In social and behavioral sciences, the raw data consist of a lot of stimuli and a lot of response in reaction to these stimuli (Torgerson, 1958, p. 96). So, there are two experimental methods in scaling, named stimuli (judicial) and response-centered approaches (Turgut & Baykul, 1992, p. 15; Torgerson, 1958, p. 94). The judgment methods is described the quantitative/fractionation judgment methods and methods based on the Thurstone model (Zinnes, 1961). On judiciary-based approach, judgmental decisions are taken as basis. Judgmental observer determines the position of each stimulant in the scale comparing with other stimulants. As a result, the average value of the judgments of the observer will set the scale value of the stimuli. According to recently some researcers, classification, sorting, paired comparison (Acar-Guvendir & Ozer-Ozkan, 2013; Kan, 2008) and absolute judgments (Arık & Kutlu, 2013) are examples of this type of approach. Based on Torgerson (1958)'s definations, the response approach is defined as positioning each stimulant in the scaling dimension in its place in the same dimension rather than determining the positions of the stimuli in the scaling dimension (Acar-Guvendir & Ozer-Ozkan, 2013). Attitude scale development process with Likert method (Anıl & Guler, 2006) and multi-dimensional sampling may be given as examples for the response approach (Arık & Kutlu, 2013).

"Paired comparison method", one of the scaling methods which is encountered on a judgmental basis, was proposed as a statistical model in 1972 (Turgut &Baykul, 1992). Scaling with paired comparison is one of the psychometric scaling methods put forward for assessing psychological events in late 1920's (Guilford, 1928, 1954 cited Neuman, 2003). Brown and Peterson (2009) argue that this method is advantageous because of its simplicity and inclusion of all of the comparative judgments (Acar-Guvendir & Ozer-Ozkan, 2013). Although this method is the basis of psychometrics, it has limited application in experimental and social psychology. Paired comparison emerges as an alternative distinction process for sensory perceptions that are hard to uncover directly (Courcoux,

This study has been realized in the process of "Comparison of Classical Test Hypothesis and Item Response Theory in terms of Test Development Process", which is supported in the scope of TUBITAK BIDEB 2219 "Post-doctorate Research Scholarship Program Abroad" with the number 1059B191400868.

Chaunier, Valle, Lourdin & Semenou, 2005). The value of the scaling with paired comparison provides us with rough statistics and produce conceptual significance results (Neuman, 2003). Thurstone indicates that this method can be used in each case that can be given to individuals in pairs to make comparisons of the stimuli (Turgut & Baykul, 1992). This method, used in most applications of frequency, is sometimes called 2-AFC (Two-alternative forced choice). These approaches are widely used in the evaluation of complex affective characteristics, while there may be difficulties in a clear assessment of the existing features. For example, two very close perceptions in the literature may not be distinguished clearly due to this affinity (Courcoux, Chaunier, Valle, Lourdin & Semenou, 2005).

1.1. The purpose and question of the research

In this study, the paired comparison method, which is rare in the literature, was used to reveal the reasons for primary school students' mathematics anxiety. Although the reasons for mathematics anxiety take place in the literature, they are not adequately studied, and this study has been thought to be necessary since this anxiety is encountered in our environment and its reasons are not fully determined. Using the paired comparison method, the data are obtained with the binaries which are easier to answer for the students and that can express the reasons for mathematics anxiety in a simpler manner. With this scaling method, looking at the consistency between the stimuli which are created to reveal the reasons for mathematics anxiety, the data about whether the items of the scale are consistent with each other or not and to what extent they are consistent will be obtained. It will also give insight into the reasons for students' anxiety. For this purpose, research question was defined as;

"What is the nature of the loads of the stimuli in the paried comparison method that is used to determine the reasons of secondary school students' anxiety in mathematics?"

2. Method

2.1. Type of research;

The aim of this research is to have secondary school students put the reasons for anxiety in mathematics in order of importance and to scale these items with paired comparison method. Because of the fact that the existing situation is described in its own terms, this study carries a descriptive nature. (Karasar, 2010, p. 29).

2.2. Study Group;

The study group consists of 243 students, who are studying at two secondary schools in Boyabat district of Sinop Province. In this study, 24 of the students who are at the secondary school were taken from 5th grades, 71 students from 6th grade, 104 students from 7th grade, and 44 students from 8th grade.

2.3. Data Collection Tool;

Many studies about mathematics anxiety were used in the preparation of the measurement tools. In this process, three teachers were asked their opinions, and opinions of five secondary school students were benefited from. Afterwards, the literature was referred regarding paired comparison method, 16 items were written about mathematics anxiety. With the help of two experts, necessary corrections were made on these items. Then, 10 students from the secondary school we took our samples were asked to order these items. First seven of the items ordered were selected as stimulus and a suitable template was created for these items with their instructions for paired comparison. All students were given brief information about the type of scale and shown the way on how it should be filled with instructions. The students were asked to think why they were anxious about mathematics and to compare the stimulus they primarily chose with the other stimuli in a binary way. The Mathematics Anxiety

Reasons Determination Form, which included the seven stimuli determined by this method, that was prepared with the paired comparison method and that consisted of 21 comparisons, was presented to the students.

2.4. Analysis of the data;

In this study, The Mathematics Anxiety Reasons Determination Form was first scaled with the case V of Thurstone's comparative judgment law since it is simpler and then with case III using a full data matrix. For this purpose, the frequency values of the students' paired comparisons of seven mathematics anxiety reasons were primarily determined, and then a frequency matrix was created with these values. Each element of the frequency matrix was divided by the total number of students who made the paired comparisons, and the matrix of ratios was obtained. Determining the z values corresponding to the elements of the matrix of ratios, the formation of unit normal determination matrix was started. The sum of the values belonging to each column was taken to the bottom line of the unit normal detection matrix and the average of each z value in this line was calculated along the columns and thus, the scale values for the case V was found. To shift the starting point of the axis to the smallest mean value of z, the absolute value of the smallest average z value was added to all the values and scale values were listed. Finally, the scale values obtained were shown on the number line.

Calculation of the internal consistency of the scale values is performed by calculating the compatibility level of the observed frequency ratios with the observed frequency ratios obtained from the scale values (Turgut & Baykul, 1992). For this purpose, moving from the scale values obtained from the analysis of application data, a Z unit normal deviation matrix and from this, a matrix of theoretical ratios was created. The compliance between observed and theoretical ratios was measured. In this case, the average error of the scale values was primarily calculated and then the matrix of transformed ratios and the matrix of theoretical ratios were obtained and the differences of these matrices were taken. By squaring the last matrix obtained and adding these values and dividing them by two, the Chi-square value was determined. The chi-square values found were compared with the table values by the significance level determined on the relevant degree of freedom. While the fact that the calculated chi-square statistical value is lower than the table value indicates that the scale has internal consistency (Turgut & Baykul, 1992; Ogretmen, 2008), its being higher than the critical value indicates that it does not have consistency. Therefore, scaling steps were carried out for the cae III in order to see whether the relaxation of the assumption of data variance equality add consistency to the model or not. The procedures up to the phase of finding Z matrix for the case III were performed just the same, and then Z matrix was squared. For this phase, the matrix of variance was obtained by finding Vj,1/K*Vj and K*C values. The standard deviation was obtained from the matrix of the variances, and a new matrix was formed by the cell-by-cell multiplication of this matrix and Z matrix. The smallest z average value was added to the resulting value by dividing the sum of the values belonging to the columns in the matrix by the number of items. The end values are shown in the number line. The values obtained from the case III and case V were compared.

3. Finding

In this section of the research, the results of the scaling belonging to the reasons for the secondary school students' mathematics anxiety are presented using the paired comparison method. By moving the starting point of the axis of the Z values of the scale values for the case V, Sj scale values were obtained. Finally, the obtained scale values are shown in the number line.

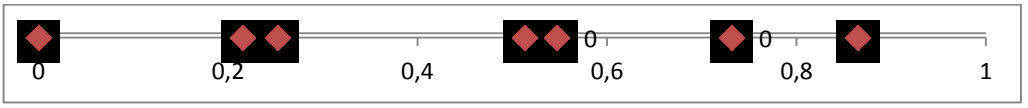

Figure 1: Presentation of seven items for Mathematics Anxiety on the number line (For case V)

Looking at the table regarding the seven items, we see that the first item is the most important stimulus about the reasons for mathematics anxiety. We can say that the item that is ranked at the bottom in order of importance in mathematics anxiety was "falling from the teacher's grace". Examining the scale values, we see that items 2 and 7, and 3 and 6 are highly close to each other. When we look at the internal consistency for the case V primarily, the chi-square values are significant. Therefore, the data is may not be one-dimensional or the assumptions of the case V may not be achieved.

Table 1. Scale values for the seven items obtained from the scaling with the case V.

Stimuli	Scale Values	Order of Importance
1) I think nothing will come to my mind in mathematics exam.	0	1
2) I can not decide what operations I will use.	0,252485	3
3) I find most of the questions in mathematics hard and I find it difficult to understand complex questions.	0,512812	4
4) I'm afraid of solving the questions in a wrong way.	0,731727	6
5) I am afraid of being perceived by my teacher as unsuccessful when I fail to solve the problems.	0,864858	7
6) I am worried that I will not be able to receive a compense for my work even if I study maths	0,54712	5
7) I am anxious that my family expects me to have high marks from mathematics.	0,215982	2

For this reason, the scaling was performed using the case III. The scaling process obtained for the case III and the one taking place up to the Z matrix are the same, and the next process was continued with proper steps. The smallest average z value for the case III was added to the resulting value, the scale values were obtained. These values are shown in the number line.

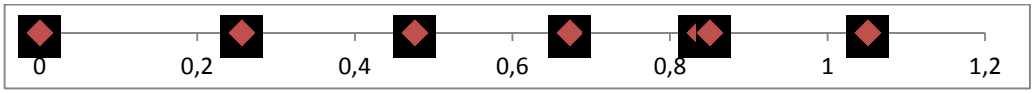

Figure 2: Presentation of the seven items regarding mathematics anxiety for the case III on the number line .

Table 2. Scale values for the seven items obtained from the scaling with the case V.

Stimuli	Scale Values	Order of Importance
1) I think nothing will come to my mind in mathematics exam.	0,256232	2
2) I can not decide what operations I will use.	0,475461	3
3) I find most of the questions in mathematics hard and I find it difficult to understand complex questions.	0,672184	4
4) I'm afraid of solving the questions in a wrong way.	0,837603	5
5) I am afraid of being perceived by my teacher as unsuccessful when I fail to solve the problems.	1,050603	7
6) I am worried that I will not be able to receive a compense for my work even if I study maths	0,850618	6
7) I am anxious that my family expects me to have high marks from mathematics.	0	1

Looking at Table 2, according to the case III scaling method, we see that the seventh item is the most significant stimulus regarding the reasons for mathematics anxiety among the seven items. We can say that the item "I am anxious that my family expects me to have high marks from mathematics" is the most distinctive. It can be seen that the item located at the bottom of the scale in order of significance in terms of mathematics anxiety is the stimulus "I am afraid of being perceived by my teacher as unsuccessful when I fail to solve the problems." Examining the scale values, we can say that the scale values of items 4 and 6 are close to each other according the case III scaling. However, we cannot state that the closeness of these values is a difference that will be an extreme obstacle in the distinction.

4. Results

In the research, the scaling was performed as a result of the secondary school students' comparison of "the reasons for mathematics anxiety". Procedures were carried out in the scaling steps both for the case V and the case III. Moving from the case V to the case III, that is, including the variances in the procedure not only changed the position of the stimuli in the scaling dimension, but also caused a differentiation in the scaling spaces. This shows that the differences between the variances are fairly big. Therefore, when the differences between the variances are so big, although scaling with the case V provides convenience, it causes big errors in scale values. For this reason, choosing the case III method for this data set will be more meaningful. Thus, it was seen that the responses for the items as a result of the scaling done with the case III were distinguished from each other more clearly. According to this study, we can express that the stimuli specified for the reasons for students' mathematics anxiety are distinctive.

Due to the fact that families want their children to have a decent job, families may put pressure on the students with the idea that they will reach their goals more easily if they succeed in mathematics. The item "I am anxious that my family expects me to have high marks from mathematics." emerges as the most significant reason for anxiety, which was obtained with the case III. There are a lot of studies available in the literature that argue that families play an important role in the formation of mathematics anxiety (Basar, Unal & Yalcin, 2002; Alkan, 2010; Kececi, 2011). It is obvious that the items obtained by this scaling method will apply to the regions having a similar socio-economic structure. With the paired comparison, students can put forth the situations that they find difficult to express not only in an easier way but also with more definite distinctions.

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