# Brief Report: Psychometric Properties of Bi-Dimensional Mathematics, Anxiety Scale in Iranian Adolescents

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**Abstract:** The purpose of this study was to evaluate validity and reliability of the Bi-dimensional Mathematics Anxiety Scale (MAS-R) in Iranian adolescents. To this end, 436, 9th grade male students were selected through cluster sampling and responded to a survey which consisted of mathematics anxiety scale (Kazelskis, 1998), 'Bi-dimensional mathematics anxiety scale (Bai et al, 2009), and mathematics self-efficacy scale (researcher – constructed). Exploratory and confirmatory factor analyses revealed that Persian version of Bi-dimensional mathematics anxiety scale consists of two stable factors of negative affect and positive affect toward mathematics. Convergent validity was confirmed by the positive correlation between measures of this scale and Kazelskis scale. Divergent validity was demonstrated by negative associations of the measures of MAS-R with mathematics self-efficacy and mathematics achievement. Test-retest and internal consistency (Cronbach's alpha) coefficients demonstrated the reliability of the scale. These results indicate that Bi-dimensional mathematics anxiety scale (MAS-R) has acceptable validity and reliability in Iranian high school students and could be used in clinical and investigational applications.

**KEYWORDS**: Mathematics Anxiety, Mathematics Self-Efficacy, Mathematics Achievement, Psychometric Properties

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## 1. INTRODUCTION

Mathematics is one of the most basic courses in virtually all school levels from elementary school up to higher education (Baloglu & Kocak, 2006). Thus, mathematics achievement has become a concern in educational systems all over the word. Many people believe intellectual ability to be a necessity in learning mathematics and affective factors is not taken into account. Even so, Suinn and Edwards (1982) argue that more than half of the academic achievement variance in mathematics is explained by variables other than cognitive abilities, particularly by affective variables. Mathematics anxiety is a key affective-emotional variable that had not been taken into account until 1960s but recently a growing attention is being paid to it (Ignacio, et al., 2006; Zan, et al., 2006). Ma and Xu (2004) define mathematics anxiety as "discomfort state created when students are required to perform mathematical tasks". According to Iossi (2007) mathematics anxiety is responsible of the worrying statistics of academic failure in mathematics. Therefore, research on mathematics anxiety is important in order to comprehend its dimensions and consequently to prevent and treat it (Ashcraft and Moore, 2009).

One of the greatest difficulties in mathematics anxiety is its manner of assessment (Baloglu, 2010). There are two conventional methods of assessing mathematics anxiety: First, scoring the amount of the person's anxiety in mathematics-related contexts, for instance, the moment of attendance in mathematics class, solving mathematical problems etc. Second, considering mathematics as a latent variable and assessing anxiety indicators such as the person's attitude toward and reaction to mathematics-related contexts (Dede, 2008). Failure to provide a tangible concept of anxiety along with different interpretations of the concept is the potential pitfalls of the first method. While psychologists believe to be in favor of the second method (Truttschel, 1992, cited in Dede, 2008), this method takes into account only the negative reactions to mathematics as anxiety indicator. As a result it will overestimate the anxiety in persons with higher anxiety and underestimate it in persons with lower anxiety. Therefore some researchers suggest having a Bi-dimensional scale and assessing the positive indicators as well as negative ones and considering lower marks in the positive indicators as the symptoms of anxiety (Kazelskis, 1998; Bai et al, 2009). Revising Betz's mathematics anxiety scale (MAS) (1978), Bai et al. (2009) provided the Bi-dimensional mathematics anxiety scale (MAS-R) based on the Watson's positive and negative affect theory (1988) and studied its psychometric properties in the college student sample. Bai (2010) also reported acceptable validity and reliability for this scale in high school students.

In Iran, mathematics achievement is considered as a sign of intelligence and according to the official reports (www.Iea.nl/timss 2007) failure rate in mathematics is high. It seems that mathematics anxiety among Iranian students is high and therefore it is important to identify its reason.

The purpose of this study is to determine the validity and reliability of Persian version of Bi-dimensional Mathematics Anxiety Scale (Bai et al, 2009; Bai, 2010) among Iranian 9th grade high school students. We predicted that the translated scale would comprise of two dimensions corresponding negative and positive affect and the structure is stable and generalizable. It is also hypothesized that the scores in Bi-dimensional mathematics anxiety scale have a positive correlation with the scores in the other mathematics anxiety scales (Kazelskis, 1998). By verifying the previously mentioned hypothesis, we will conclude that the Bi-dimensional scale has convergent validity. Negative correlation between mathematics anxiety and mathematics self-efficacy has been supported in several studies such as Pajares (1996), Mills, Pajares, Herron (2006) and the

researches reviewed by Mishaelides (2008). Accordingly, it is hypothesized that the scores in Bi-dimensional scale correlate negatively with mathematics self-efficacy scores. This negative correlation is considered as the sign of divergent validity of the Bi-dimensional scale. A number of research findings including all the studies discussed in Ma's meta-analysis (1999), Hopko et al. (2002); Cates and Rymer (2003) have indicated the negative correlation between mathematics anxiety and mathematics achievement. The other hypothesis is therefore that the scores on Bi-dimensional scale correlate negatively with mathematics achievement, which would be an indication of divergent validity of Bi-dimensional scale. Our expectation is that the Bi-dimensional scale among Iranian 9th grade adolescents has desirable test-retest and internal consistency coefficients.

## 2. Method

*Participants*

The sample consisted of 436 male first grade high school (9th grade) students in Tehran, which were selected through cluster sampling. The average age was 15.7 years with a standard deviation of 1.44.

*Materials*

*Mathematics achievement in the previous semester*:

For assessing the mathematics achievement, final grade point of mathematics course in the previous semester was used.

*Mathematics self-efficacy*

This scale was prepared according to Bandura's guideline (2006) for constructing self-efficacy scales and considering the content of first grade high school mathematics book such that from the outset, the final exam questions of six mathematics teachers were gathered and then an experienced mathematics teacher selected 12 questions from them. Students were required to score their assurance in answering each question from 0 to 20. Since the scale questions were constructed by experts (mathematics instructors), the scale had content validity. Construct validity was also ensured through factor analysis. Because of Eigen value above 1 (Kaiser, 1960 approach), the scale consisted of a single factor with the Eigen value of 7.14. This single factor explained 60 percent of the scale variance. Reliability coefficient was measured 0.94 through Cronbach's alpha coefficient.

*Mathematics anxiety*

Two scales were used for assessing mathematics anxiety, Kazelskis' Mathematics Anxiety Scale and Bi-dimensional Mathematics Anxiety Scale (MAS-R) (Bai et al., 2009).

*Kazelskis' Mathematics Anxiety Scale*

This 43-item scale has been devised by Kazelskis (1998). In the present study, we utilized Persian version of this scale whose psychometric properties were previously examined by Razavie, Seyf and Emami (2007). The Scale items were undergone a factor analysis with Varimax rotation and regarding the Eigen value above 1, consistent with Kazelskis research (1998), six factors were recognized which explained 53 percent of variance. These 6 factors are as follows: Mathematics Test Anxiety, Numerical Anxiety, Mathematics Course Anxiety, Worry, Positive Affect toward Mathematics, and Negative Affect toward Mathematics. Reliability coefficients of these factors and the whole scale were 0.79, 0.86, 0.79, 0.67, 0.74, 0.84 and 0.92respectively.

*Bi-dimensional Mathematics Anxiety Scale (MAS-R)*

This 14-item scale has been devised in five point Likert scale by Bai et al. (2009) in order to remove the shortcomings of MAS scale (Betz, 1978) and to make it Bi-dimensional on the basis of Watson's positive and negative affect theory (1988). For scoring the scale, the items related to the positive affect toward mathematics are scored reversely. Using factor analysis, Bai et al. (2009) indicated existence of the two factors of negative and positive affect toward mathematics. These two factors explained the

66.7 percent of variance. By the use of Cronbach's alpha, the reliability of the whole scale was measured 0.91 and through Parallel-item Consistency it was measured 0.87. In the present study the scale was first translated through Parallel-translation, such that two English language experts translated the scale separately. Then through contrasting the two translations, the third expert looked for the discrepancies, if existed, removed them and selected the best translation of items. Afterwards three first grade high school students were provided with the translation and then the final version of the scale was prepared.

*Procedure*

A survey questionnaire composed of the MAS-R (Bai et al., 2009) Kazelskis' Mathematics Anxiety Scale (1998), and Mathematics self-efficacy (based on Bandura's guideline, 2006) was administrated to the students during the second session in class by a graduate student in psychology. Two forms of the questionnaire, with the subscales in different order, were administrated to distribute effect on scales (to minimize any effects that one scale may have on another scale).

## 3. RESULTS AND DISCUSSION

*Factor Structure of the scale*

For determining the validity of the scale, half of the sample (n= 219) was selected randomly at first. The factor analysis with Oblimin rotation was used to ensure validity. The rationale behind using the oblique rotation was that those who construct the scale view it as consisting of two correlated factors. 14 items of the scale were used in the analysis. The value of correlation matrix determinant was a non-zero value, (0.008) which indicated the possibility of measuring the reverse of matrix and therefore made it possible for factors to be extracted. The value of KMO (0.874) yielded the adequacy of sampling and significance of Barttlet test of sphericity (913.42, $p<0.001$) which signified that the correlation matrix of data was not zero and as a result the factor extraction was justifiable. Considering the Eigen value above 1 (Kaiser's (1960) method), two factors were determined. These factors regarding the theoretical basis were called negative affect and positive affect toward mathematics. In this phase, the item "I find mathematics challenging" which in the original scale was related to the first factor (negative affect), had a negative factor loading on the concerning factor. The possible reason of this might be that the word "challenging" in this item, which has a negative meaning in English, does not have an exact positive or negative meaning in Persian. Accordingly, this item was omitted and the factor analysis was presented for the second time. Also in this phase, the value of correlation matrix determinant was a non-zero value (0.010), KMO measure 0.876 and the value of Barttlet test of sphericity was significant (870.2, $p<0.001$). The results of factor analysis on the rest 13 items are presented in Table 1.

Table 1: Factor loadings of 13 remaining items of MAS-R scale with oblimin rotation (n=219)

| Item number | Factor1 Negative Affect | Factor 2 Positive Affect |
|---|---|---|
| 2 | 0.769 | |
| 7 | 0.734 | |
| 4 | 0.705 | |
| 6 | 0.704 | |
| 9 | 0.632 | |
| 11 | 0.601 | |
| 14 | 0.549 | |
| 13 | | |
| 1 | | 0.713 |
| 12 | | 0.681 |
| 10 | | 0.666 |
| 5 | | 0.641 |
| 3 | | 0.596 |
| Initial Eigen value | 4.77 | 1.99 |
| Variance explained | %36.73 | %15.34 |
| Total Variance explained | %36.73 | %52.07 |

Note: factor loadings below 0.35 are omitted

According to Table 1, items of MAS-R scale load on two factors. Negative affect toward mathematics as the first extracted factor and positive affect as the second extracted factor, in the aggregate, constitute 52.07 percent of variance. In order to investigate stability and invariance of scale's factor structure, confirmatory factor analysis was used conducting maximum likelihood method for the remaining half of the sample (n=217). The model fit indices for on and two factors model presented in table 2, support better fitness of two factors model ($\Delta x^2$ = 138.52, df =1, p< 0.001) and indicates factor structure's stability and invariance across two samples.

Table 2: Model fit indices for one and two factors models

| Models | $x^2$/df | CFI | GFI | AGFI | RMSE |
|---|---|---|---|---|---|
| One factor model | 3.62 | 0.80 | 0.81 | 0.74 | 0.11 |
| Two factor | 1.51 | 0.96 | 0.93 | 0.91 | 0.05 |

*Convergent and divergent validity evidence*

In order to determine the convergent validity of the scale, the mutual correlations of the overall score and the subscales of Bi-dimensional scale (MAS-R) with the overall score and the subscales of the Kazelskis (1998) mathematics anxiety scale have been measured and presented in Table 2.

As it is demonstrated, all of the correlations, except for two cases, are positive and significant. Correlation of the two scales' overall score is positive and above the average (r=0.59, p<0.01). Correlation of the negative effect in the two scales is measured 0.78 and positive affect is measured 0.52 such that the both are significant in 0.01 levels. These coefficients yield for the convergence of the overall and subscales of the two scales and indicate the convergent validity of the Bi-dimensional scale.

Also for determining divergent validity of the scale, two variables of mathematics self-efficacy and mathematics achievement, in the previous semester were used. As it is presented in Table 3, correlation between these scores and subscales and the overall mathematics anxiety scale is negative and significant. Accordingly the scale's divergent validity is concluded.

Table 3: The correlations between subscales and the whole scales of MAS-R and Kazelskis scale

| Factors | positive affect | negative affect | MAS-R overall scores |
|---|---|---|---|
| 1- Negative Affect | 0.47** | **0.78**** | 0.74** |
| 2-Numerical Anxiety | 0.15** | 0.34** | 0.29** |
| 3-Mathematics Test anxiety | 0.11* | 0.39** | 0.30** |
| 4-Mathematics Course Anxiety | 0.07ns | 0.35** | 0.26** |
| 5- Positive Affect | **0.52**** | 0.47** | 0.58** |
| 6-Worry | 0.08ns | 0.29** | 0.14** |
| 7- overall score | 0.33** | 0.66** | **0.59**** |

Note: *: p<0.05, **: p<0.01, ns: no significant.

*Reliability evidence*

For determining reliability, Cronbach's alpha and test-retest in a two-week interval were used. Table 4 demonstrates these coefficients. According to table 4, coefficients represent high internal consistency and test-retest reliability for total and two subscales of the scale.

Table 4: correlations between MAS-R scales and mathematics self-efficacy and mathematics achievement in the previous semester

| Factor | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1-positive affect | - | | | | |
| 2-negative affect | 0.46** | - | | | |
| 3-overall mathematics anxiety scale | 0.83** | 0.88** | - | | |
| 4-mathematics self-efficacy | -0.43** | -0.36** | -0.46** | - | |
| 5-mathematics achievement in the previous semester | -0.35** | -0.29** | -0.37** | 0.52** | - |

Note: **: p<0.01

Table 5: Alpha and test-retest coefficients

| Method | Negative affect | Positive affect | Overall MAS-R score |
|---|---|---|---|
| Test-retest(n= 27) | 0.77** | 0.75** | 0.83** |
| Cronbach's alpha(n= 436) | 0.83 | 0.79 | 0.86 |

**: p<0.01

## 4. CONCLUSION

The evidence supports the hypotheses and is in line with findings of the previous research. The factor structure of Persian version of MAS-R consisted of two dimensions of negative affect and positive affect toward mathematics, which have a good fit to the data. Convergent validity between two dimensions of MAS-R and Kazelskis mathematics anxiety scale on the one hand and divergent validity with mathematics self-efficacy and math achievement, on the other hand was demonstrated. The test-retest and internal-consistency (Cronbach's alpha) coefficients also signified acceptable reliability of the scale. These findings generally converged with findings of the studies conducted by Bai et al. (2009) and Bai (2010) and the previous findings on relationship between mathematics anxiety, academic achievement and mathematics self-efficacy.

Based on the above evidence it can be surmised that Persian version of Bi-dimensional mathematics anxiety scale in Iranian 9th grade adolescents has an acceptable validity and reliability and it can be used for research purposes, and by school psychologist.

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