Subjective and Objective Assessment of Mathematics Anxiety Levels among College Students

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Abstract

The study investigated the relationship between college students' subjective and objective assessment of mathematics anxiety levels. Students rated their general and current mathematics anxiety levels, mathematical ability levels, and confidence in doing mathematics. The Revised Mathematics Anxiety Rating Scale was used as an objective measure of their mathematics anxiety levels. Participants were 559 students, 406 (72.6%) women and 151 (27.0%) men. Results showed that perceived general mathematics anxiety had a mean of 49.69 (SD = 29.87, Median = 50.00). Current mathematics anxiety had a mean of 47.74 (SD = 33.53, Median = 50.00). Positive correlations between the subjective and objective measures were found which indicates that students' subjective judgments and ratings form the objective measure are in the same direction. Correlations varied from low to medium, which indicates the validity of the objective measure and the possibility that in the absence of an objective measure, subjective assessment might be a useful indicator.

Keywrds: Mathematics anxiety, college students, objective assessment, subjective assessment

Introduction

Mathematics in everyday life is more essential than ever (Oropesa, 1993). In higher education, many disciplines require mathematics courses (Committee on Undergraduate Program in Mathematics, 1989; National Research Council, 1991). Oropesa (1993) predicted that over 50% of the students enrolled in mathematics courses are social science majors and enroll in these courses under-prepared. Consequently, student difficulties were reported with mathematics courses (i.e., Hembree, 1990; Oropesa, 1993; Skiba, 1990).

Student difficulties in mathematics are hypothesized to be mostly attitudinal in nature (Aiken, 1970a, Aiken, 1970b; Richardson & Suinn, 1972). Suinn and Edwards (1982) explained that about half of the variance in mathematics achievement could be accounted for by factors other than intellectual ones. Mathematics anxiety is one of these common attitudinal factors. In 1957, Dreger and Aiken introduced "mathematics anxiety" as a new term to describe students' attitudinal difficulties with mathematics. They defined mathematics anxiety as "the presence of a syndrome of emotional reactions to arithmetic and mathematics" (p. 344). They found that 35% of students showed high levels of mathematics anxiety.

Historically, Atkinson (1988) described three distinct periods in the measurement of mathematics anxiety. In the first period, most studies were merely based on opinions and did not employ any standardized mathematics anxiety measures.

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During this period, an awareness of anxiety about mathematics arose, and mathematics anxiety was defined (e.g. Gough, 1954). Next, studies focused on assessing attitudes toward mathematics through surveys that included several variables such as state-trait anxiety, confidence, enjoyment, misconceptions, and attitudes toward mathematics (e.g., Dutton & Blum, 1968). The third period led to the development of standardized mathematics anxiety instruments. The first instrument, the Number Anxiety Scale, was developed by Dreger and Aiken in 1957. Afterwards, more comprehensive scales such as the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), the Anxiety Toward Mathematics Scale (Sandman, 1980) and the Mathematics Anxiety Questionnaire (Wigfield & Meece, 1988) were developed. Since then, mathematics anxiety levels can be measured by two common techniques: subjective and objective measurement. In subjective way of measuring anxiety, students are directly asked to indicate how anxious they are under mathematics involved situations. On the other hand, objective way of measurement usually includes some sort of paper-pencil tests under standardized conditions where students respond to several written items.

Under certain circumstances (i.e., lack of financial sources or objective assessment instruments or time constraints), it is impossible to use a standardized, objective measure in the assessment process. It will be worthwhile to know the degree of the relationship (if any) between an objective and subjective assessment in mathematics anxiety.

Thus, in the present study, subjective and objective measurements of mathematics anxiety levels were studied to examine the overlap between the two. It is expected that objective and subjective measures of mathematics anxiety will significantly positively correlate. More specifically, it is expected that objective measure will be related to perceived current mathematics anxiety scores and that students who are enrolled in mathematics courses will score higher both on the objective and subjective measures than students who are not enrolled in such courses.

Method

Participants

Participants of the present study were college students who were attending classes in 3 southwestern state universities in the USA. The sample of the study was formed by convenient sampling method where voluntary students participated in the study. Of the total 559 students, 406 (72.6%) were women and 151 (27.0%) were men. Two students (0.4%) did not indicate their gender. Participants' ages ranged from 17 to 62 years with a mean of 25.69 (SD = 9.05). In this group, there were 121 (21.6%) freshmen, 81 (14.5%) sophomores, 149 (26.7%) juniors, 112 (20.0%) seniors, and 95 (17.0%) graduate students. One student (0.2%) did not indicate his/her college status. In the group, 299 (53.5 %) students were not enrolled in a mathematics course and 260 (46.5%) were enrolled in a mathematics course at the time of the administration.

Instruments

A survey packet that included demographic items (i.e., age, gender, Grade Point Average-GPA); rating questions; and the Revised Mathematics Anxiety Rating Scale (RMARS) were used to collect data in the present study. As a subjective assessment, students were asked to rate their general mathematics anxiety levels, current mathematics anxiety levels, mathematical ability levels compared to other students in their majors, and confidence in doing mathematics on a scale between 0 and 100, higher scores referring to more general and current mathematics anxiety, higher mathematical ability, and confidence, respectively. For example, students were asked: "Indicate your CURRENT mathematics anxiety level by entering any number between 0 and 100, where 0 is "no math anxiety at all" and 100 is "the severest math anxiety possible." or "Indicate your own mathematics ABILITY compared to other students in your major by entering any number between 0 and 100, where 0 is "no math ability at all" and 100 is "the highest math ability possible."

As an objective measure of the levels of mathematics anxiety, the RMARS was used to measure the amount of mathematics anxiety students "usually" experience. The RMARS, a 25-item, 5-point, Likert-type scale, has three subscales: Mathematics Test Anxiety (15 items), Numerical Task Anxiety (5 items), and Mathematics Course Anxiety (5 items) (Alexander & Martray, 1989). Higher scores in the subscales and the total scale indicate higher levels of mathematics anxiety. The Mathematics Test Anxiety subscale assesses student reactions to evaluative situations related to mathematics. The Mathematics Course Anxiety subscale assesses student reactions that are related to being in a mathematics class. The Numerical Task Anxiety subscale measures anxiety that arises due to basic mathematical activities such as multiplication and division.

Psychometric properties of the scale have been investigated and results were reported in the literature. For example, Construct validity of the instrument was obtained from a sample of 517 undergraduate students. An abbreviated version of the MARS (69-item) that was obtained from a principal component factor analysis was found to be "psychometrically equivalent" to the original MARS (i.e., the correlation coefficient between the two was .93) and used in the study (Alexander & Martray, 1989). A principal component factor analysis with squared multiple correlations as the initial communality estimates of the 69-item version MARS revealed three factors. These three factors (Mathematics Test Anxiety, Numerical Task Anxiety, and Mathematics Course Anxiety) accounted for 31% of the variance in the RMARS scores. After a varimax rotation, Mathematics Test Anxiety (15 items), Numerical Task Anxiety (5 items), and Mathematics Course Anxiety (5 items) were found to be three distinct dimensions.

Concurrent validity of the instrument was tested by comparing it with the 69-item MARS. This comparison evidenced the RMARS' validity ($r = .93$, $p < .01$). In addition, the RMARS was compared with the Fennema-Sherman Attitude Scale (1976) and negative relationships were found, which meant that students who had more favorable attitudes toward mathematics experienced less mathematics anxiety. Moore, Alexander, Redfield, and Martray (1988) found high-to-moderate correlations between

the RMARS and the Mathematics Anxiety Scale (Fennema & Sherman, 1976), the State-Trait Anxiety Inventory (Spielberger et al., 1983), and the Test Anxiety Inventory (Spielberger, 1980). Alexander and Martray (1989) also found that the RMARS discriminated between students who took geometry or algebra in high school and students who did not. Students who took an algebra ($F = 18.07$, $p < .001$) and a geometry ($F = 25.60$, $p < .001$) course in high school experienced significantly less mathematics anxiety compared to students who did not take these courses. Finally, Moore et al. (1988) revealed that the RMARS scores were significantly correlated with the ACT mathematics scores and mathematics course grades.

In a recent study, the psychometric properties (i.e., validity and reliability) of the RMARS were investigated through the responses of 805 college students (Baloglu, 2002). The instrument's construct validity was tested through a confirmatory factor analysis (CFA) and was found [Normed Fit Index (NFI) = .86; Non-normed Fit Index (NNFI) = .87; Comparative Fit Index (CFI) = .87; Incremental Fit Index (IFI) = .88; Root Mean Square Error of Approximation (RMSEA) = .09). An exploratory factor analysis suggested a modification by dropping five of the Mathematics Test Anxiety items (loadings < .60). After the modification, a second CFA of the modified model showed that the modified model fit the theoretical model well (NFI = .90; NNFI = .90; CFI = .92; IFI = .92; RMSEA = .09). Cross-validation of the modified model was tested on a different sample of 246 students and was also found to be satisfactory (NFI = .89; NNFI = .93; CFI = .94; IFI = .94; RMSEA = .07). Reliability coefficients (i.e., internal consistency, split-half, and parallel-model) indicated the consistency of the modified RMARS items (reliability coefficients > .85). In the present study, the internal consistency of the scale was found to be .95 (.95 for the Mathematics Test Anxiety; .91 for the Numerical Task Anxiety; and .88 for the Mathematics Course Anxiety). The present study used the modified RMARS as an objective measure of students' mathematics anxiety levels.

Procedure

After the permission to use and duplicate the RMARS was obtained from its author, survey packets that included the demographic questions, rating items, and the RMARS were assembled. Additionally, a separate consent form and a multiple-choice answer sheet were included with all packets.

Mathematics instructors were informed about the purpose of the study and given a sample survey packet. If the instructors agreed, a schedule for the administration was made. The principal researcher conducted the administrations. In cases when the principal researcher was not available for administration, mathematics instructors conducted the administrations.

Prospective participants were contacted in their classes and informed about the study (took approximately 10 minutes). In order to ensure confidentiality, participants were asked not to write identifying information on the packets. After ensuring confidentiality and explaining that participation was voluntary, students were asked whether they were willing to participate or not. In most administrations, students

completed the packets during the first or last 20 minutes of the class time. After the completion of the packets, participants returned the packets and were debriefed at that time. The debriefing included a statement of appreciation for participation and a brief description of the study. Participants were informed that they could obtain a copy of the results at the end of the study by contacting the researcher. All students were given extra course credit for their participation in the study.

Hardcopies of the multiple answer sheets were eye-scanned for missing sheet(s) and/or unusable form(s). Data were coded onto the Statistical Package for Social Sciences (SPSS) 10.0 (1998) and were analyzed by parametric statistics.

Results

Students' self-reported grade point averages (GPAs) ranged from 1.00 to 4.00 with a mean of 3.19 (*SD* = .53) and a median of 3.20 (*Q* = .35). Students also rated their perceived mathematical abilities, confidence (in doing mathematics), general mathematics anxiety levels, and current mathematics anxiety levels on a scale between 0 and 100, higher scores referring to higher mathematical ability, higher confidence and more general and current mathematics anxiety levels.

Students' perceived mathematical ability levels ranged from 0 to 100 with a mean of 63.46 (*SD* = 20.52, Median = 70.00) so did confidence ratings ($\overline{X}$ = 64.05, *SD* = 23.98, Median = 70.00). General mathematics anxiety ratings ranged from 0 to 100 with a mean of 49.69 (*SD* = 29.87, Median = 50.00). Current mathematics anxiety ratings also ranged from 0 to 100 with a mean of 47.74 (*SD* = 33.53, Median = 50.00). The relationships between the students' subjective evaluations of their mathematics anxiety levels and objective evaluations were reported in Table 1.

Table 1. Pearson Product-Moment correlation coefficients between the subjective and objective measures

Objective Measures	**Subjective Measures** [a]			
	General Mathematics Anxiety	**Current Mathematics Anxiety**	**Perceived Mathematics Ability**	**Confidence in Mathematics**
Total RMARS	.70	.66	-.33	-.51
Mathematics Test Anxiety	.69	.65	-.32	-.50
Numerical Task Anxiety	.31	.31	-.22	-.24
Mathematics Course Anxiety	.52	.47	-.22	-.37

[a] All coefficients are significant at $p < .01$

Table 1 shows that objective measure and subjective assessment scores relate significantly positively as expected. The smallest relationship was between general mathematics anxiety or current mathematics anxiety and the Numerical Task Anxiety

subscale. As expected, there found to be negative relationships between perceived mathematics ability and mathematics anxiety levels as measured by the RMARS. Similarly, negative relationships were found between confidence in mathematics and mathematics anxiety levels.

Students who were enrolled in a mathematics course at the time of the administration were compared with the students who were not enrolled in such a course on objective and subjective mathematics anxiety ratings (subscales included), perceived mathematics ability, and mathematics confidence. Table 2 shows the descriptive results between the two groups.

Table 2. Group comparisons

	Enrolled			**Not Enrolled**		
	n	Mean	S.D		Mean	S.D
Total RMARS	59	7.75	9.18	99	4.70	9.29
Mathematics Test Anxiety*	59	9.65	4.08	99	6.65	3.94
Numerical Task Anxiety	59	7.82	3.73	99	7.52	3.90
Mathematics Course Anxiety	59	0.69	4.83	99	0.54	4.66
General Mathematics Anxiety	55	1.83	9.17	91	7.81	0.44
Current Mathematics Anxiety**	56	8.37	1.41	91	8.38	2.64
Mathematics Ability*	53	1.40	0.78	90	5.21	0.17
Mathematics Confidence**	56	0.11	5.48	91	5.88	3.38

t differences are significant at * $p < .05$; and ** $p < .01$.

No significant *t* difference was found between the students who were taking a mathematics course and the others on the total RMARS score and the Numerical Task Anxiety and the Mathematics Course Anxiety subscales or subjective-general mathematics anxiety measure. However, students' subjective assessment of their current mathematics anxiety levels, mathematics ability, and mathematics confidence differed significantly. Students who were enrolled in a mathematics course indicated significantly higher current mathematics anxiety levels [$t_{(546)} = 7.28$, $p < .01$]; lower mathematics ability [$t_{(542)} = 2.13$, $p < .05$]; and lower mathematics confidence [$t_{(546)} = 2.74$, $p < .01$].

Discussion

The relationships between students' subjective and objective evaluations were tested by correlating the RMARS' total and subscale scores with students' perceived general and current mathematics anxiety ratings. First, it was hypothesized that the total and subscale scores of the RMARS would significantly positively correlate with the subjective measures. This expectation was found to be true by statistically significant correlations. Second, it was hypothesized that the total and subscale scores of the RMARS would correlate higher with the perceived *current* mathematics anxiety ratings because mathematics anxiety is hypothesized to be a state anxiety construct (Richardson & Suinn, 1972). However, this was not the case in the present study. Both the total and subscale scores were correlated higher with the perceived *general* mathematics anxiety ratings than *current* mathematics anxiety ratings.

One important factor related to this might be how students are directed to answer the items in the instrument. The directions in the RMARS prime students to "indicate the amount of anxiety [they] *usually* experience in each of the listed [25] situations." These directions are in contradiction with the previous research that conceptualized mathematics anxiety as a state anxiety rather than trait anxiety (i.e., Richardson & Suinn, 1972). Both Mathematics Test Anxiety and Mathematics Course Anxiety are more similar to state anxiety and thus should have correlated highly with the perceived *current* mathematics anxiety ratings, which was not found to be the case. Again, the possible reason for this finding might be the directions given to students. Another explanation is that the nature of mathematics anxiety might be trait rather than state. This means that mathematics anxiety is a more stable and longer lasting construct. This explanation is also supported in the literature (Byrd, 1982). Nonetheless, there still does not exist an agreement regarding the nature of mathematics anxiety.

Because mathematics anxiety is accepted to be a state anxiety construct, it was also hypothesized that students who were enrolled in a mathematics course at the time of the administration would show higher mathematics anxiety levels than students who were not currently taking a mathematics course. Results showed that when anxiety levels measured by the objective measure, there was not any difference between the groups. In terms of the subjective measures, students who were enrolled in a mathematics course indicated higher current anxiety levels, lower mathematics ability and lower mathematics confidence. This means that when students find themselves in anxiety producing situations (i.e. taking a mathematics course) their get anxious and this lowers their perceived ability and confidence levels. Because other students were not facing the anxiety producing situation, they felt more able and confident in mathematics.

The results of the present study indicate that there is a medium to high relationships between the objective and subjective measures. This means that in the absence of the objective measure, the subjective measures can be used (with caution) for quick assessment of mathematics anxiety.

Lastly, results indicate a need for revision in the directions of the objective mathematics measure (RMARS). Present direction primes general mathematics anxiety

levels; however, mathematics anxiety is more like a state anxiety construct as supported by the literature. The directions can be modified as "indicate the amount of anxiety *currently* experienced in each of the listed [25] situations." Further studies with modified directions should be conducted to test the changes in students' responses.

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Üniversite Öğrencilerinin Öznel ve Nesnel Matematik Kaygısı Düzeylerinin Ölçümlenmesi

Özet

Çalışmanın amacı üniversite öğrencilerinin öznel ve nesnel olarak ölçümlenmiş matematik kaygı düzeyleri arasındaki ilişkinin belirlenmesidir. Öğrencilerden durumluk ve sürekli matematik kaygısı düzeylerini, matematik beceri düzeylerini ve matematik güvenlerini kendi branşlarındaki derecelendirmeleri istenmiştir. Revize edilmiş Matematik Kaygısı Derecelendirme Ölçeği ise öğrencilerin matematik kaygı düzeylerini nesnel olarak belirleme aracı olarak kullanılmıştır. Katılan öğrencilerden 406 (72.6%)'sı kız; 151(27.0%)'i erkek idi. Sonuçlar öğrencilerin öznel sürekli matematik kaygı derecelendirmelerinin 0 ile 100 (X = 49.69, SS = 29.87, Medyan = 50.00); durumluk matematik kaygı derecelendirmelerinin ise 0 ile 100 (X = 49.69, SS = 29.87, Medyan = 50.00) arasında değiştiğini göstermiştir. Öznel ve nesnel ölçümlemeler arasında anlamlı korelasyonlar bulunmuştur. Bu korelasyonların etki değerlerinin ise düşük ile orta arasında değiştiği görülmüştür. Anlamlı korelasyonlar hem nesnel matematik kaygısı ölçeğinin geçerliğine bir delil olurken aynı zamanda da nesnel ölçüm aracı yokluğunda öznel ölçümlemenin de matematik kaygısını belirlemede faydalı bir gösterge olabileceğine işaret etmektedir. Sonuçlar bu bağlamda tartışılmaktadır.

Anahtar sözcükler: Matematik kaygısı, üniversite öğrencileri, nesnel ölçümleme