Relationship Between Mathematics Anxiety and Attitude Towards Mathematics among Indian Students

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The purpose of the study was to investigate relationship between mathematics anxiety and attitude towards mathematics among secondary school students in South India. Data were collected from 112 secondary school students in a private school. Demographic information such as gender and age of the students were also collected. Structural equation modelling was used to test the hypothesised relationships between mathematics anxiety and attitude to mathematics variables. Independent-samples *t*-tests were used to examine the differences in the measured variables based on gender and age.

Academic achievement in schools has been considered an important predictor of future success in education, occupation and life (Campbell & Mandel, 1990). In particular mathematics achievement has been found to be a significant factor in deciding the future progress of adolescents (Steinberg, Varua, & Yong, 2010). But student participation in mathematics based courses is declining from higher secondary to tertiary level and beyond (Fullarton, Walker, Ainley, & Hillman, 2003). Researchers exploring the factors hindering mathematical performance of students have identified the importance of affective and motivational factors (Pintrich & Schunk, 2002).

Mathematics anxiety

Mathematics anxiety as an affective variable has been found to influence the performance of students in mathematics (Ashcraft, 2002). Researchers have defined mathematics anxiety differently over the years e.g., Fennema & Sherman, 1976). Dreger and Aiken's (1957, p. 344) definition of the construct as "the presence of a syndrome of emotional reactions to arithmetic and mathematics and a condition in which students experience negative reactions to mathematical concepts and testing procedures" captures its essentially emotional character and has become the definition of choice (Richardson & Woolfolk, 1980).

Extensive research has been carried out to understand the influence of gender on mathematics anxiety over the years, but the findings have not been consistent. For example, some studies have found that girls experience greater mathematics anxiety than boys (e.g., Tapia, 2004), whereas other studies have failed to confirm gender differences in mathematics anxiety (Cooper & Robinson, 1989). Nevertheless, the weight of evidence suggests that female students are more likely to experience mathematics anxiety than male students. Various explanations have been proposed including the more self-critical nature of female students (Zettle & Houghton, 1998); and their lack of confidence in spite of success (Meelissen & Luyten, 2008).

The influence of age on mathematics anxiety has been studied widely by researchers, but the findings are inconsistent. Some researchers have found that older students experience higher anxiety levels towards mathematics than younger students (Dew & Galassi, 1983), and mathematics anxiety becomes more evident during teenage years. Other studies, however, were unable to confirm any significant difference in mathematics anxiety on the basis of age of the participants (Hembree, 1990; Zeinder, 1996).

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Attitude towards mathematics

Attitude towards mathematics is another affective factor that has been studied over the years in relation to mathematics achievement. Zan and Martino (2007) defined attitude towards mathematics as a positive or negative emotional disposition towards mathematics. Considering attitude towards mathematics as multidimensional, Hart (1989) described an individual's attitude towards mathematics as the emotions he or she associates with mathematics, his or her beliefs towards mathematics and how he or she behaves towards mathematics. According to Hannula (2002) students' attitudes towards mathematics can be classified under the following evaluative processes a) the emotions experienced through activities involving mathematics; b) emotions evoked by the concept 'mathematics'; c) evaluations of the consequences of doing mathematics; and d) value of mathematics to one's future goals.

Gender differences in attitude towards mathematics have also been researched widely. As in the case of mathematics anxiety, inconsistency in the results has been common. Many studies have found no significant difference in attitude towards mathematics between genders (Nicolaidu & Philippou, 2003). On the other hand, there are studies that have found significant gender differences in attitude to mathematics, with girls showing more negative attitudes towards the subject (Linn & Hyde, 1989).

Rationale of the study

Mathematics anxiety and attitude towards mathematics are two affective variables that have been studied independently and extensively in relation to mathematics learning and achievement (Zakaria & Nordin, 2008). Both have also been studied in relation to other factors. It is clear that mathematics anxiety is associated with attitudes towards mathematics, but is less comprehensive. In the study reported here, the two constructs were treated as different ideas to explore any association between them. Since very little literature is available to understand the relationship between mathematics anxiety and attitude towards mathematics, this study addresses a gap in current knowledge.

The present study

In spite of being one of the fastest growing economies, very little educational research carried out with Indian samples has been available in the Western literature. Considering the limitations of previous research, the present study explores the relationship between mathematics anxiety and attitude towards mathematics among Indian secondary school students. The influence of gender and age on the measured variables was also investigated. The study set out to test a model hypothesising a correlational relationship between the variables.

In the Asian society success has been viewed not as a personal goal but as a group goal. Individuals have to consider the expectations and wishes of the group. Interdependence rather than independence has been taught from early years. Since actions affect or connect others, keeping harmony in relationships becomes the chief goal of social life (Nisbett, 2003). In most cases, individuals are forced to act according to the expectations of the group rather than having a focus on personal goals. This behavioural style has been suspected to influence mathematics learning as well.

The education system in India is highly competitive and the students are under great pressure to achieve highly. The majority of science stream students try to get into medical colleges or engineering colleges as the engineering or medical professions are regarded as

most prestigious in India. In order to secure admission into high status institutions, students need to achieve exceptionally high grades especially in mathematics and science subjects (Cheney, Ruzzi, & Muralidharan, 2005).

Method

Participants

A total of 112 students from a private school in Kerala, South India participated in the study. The sample consisted of 45 males (40.2%) and 67 females (59.8%). The participants range in age from 14 to 17 years of age, studying in grade 9 (N=67) and grade 11 (N=45).

Instrument and procedure

The instrument used was a survey comprising 50 items taken from the Shortened Form of the Fennema-Sherman attitude Scale (Mulhern & Rae, 1998). The survey comprised two subscales, the attitude towards and success in maths (atsuc) scale, and the usefulness of mathematics (usmat) scale measuring the construct *attitude towards mathematics*. Three subscales, the confidence in mathematics (comat) scale, the anxiety (anxie) scale, and the effectance motivation in mathematics (efmot) scale, measured the construct, *mathematics anxiety*. Responses to all items were placed on a 5-point Likert scale, as used in the original instrument. According to Mulhern and Rae (1998), the Cronbach's alpha reliability coefficient for the individual scales was between 0.84 and 0.91. The reliability coefficients for the individual scales of the present study were between 0.61 and 0.83. Participants completed the survey, in English as their language of instruction, in their classrooms as whole classes.

Data analysis

Rasch measurement model. Rasch model is a measurement model which assumes that probability of passing an item depends on the ability of the person and difficulty of the item. Thus it comprises a method for ordering the persons according to their ability and ordering the items according to their difficulty, on the same measurement scale using units of logits, the logarithm of the odds of success (Bond & Fox, 2007, p.10). Data from the student survey were analysed using Partial Credit Model (PCM) (Masters, 1982). The Rasch modelling software Winsteps (Linacre, 2012) was used to estimate fit statistics, reliabilities of items and persons, and difficulty estimates. Data fit was obtained by fitting the data from the instrument to the PCM model. Items that depart from the basic assumptions of the model show up as misfitting.

Structural Equation Modelling. Structural Equation Modelling (SEM) is a statistical methodology that takes a confirmatory approach to the analysis of a structural theory bearing on some phenomenon (Byrne, 2001, p.3). AMOS 20.0 (Arbuckle, 2010) was used to test the proposed model in the present study. Rasch measures were used in the SEM analysis, as they provided a continuous interval scale suitable for SEM. Maximum likelihood estimation was employed to generate the model parameters.

A well-fitting model should yield a non-significant chi-square with $p > 0.001$. To address the limitations of the test due to sample size and central distribution, the ratio χ^2/df was taken as the reported fit statistic (Wheaton, Muthen, Alwin, & Summers, 1977). Values of < 2.00 implied a good fitting model and < 1.00 implied an over-fitting model (Bollen, 1989). The two goodness fit measures considered in this study were the Goodness

of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) having ideal values of 1.00. The RMSEA was considered as an informative estimate of model fit with a value of < 0.05 indicating a good fitting model, values of < 0.08 indicating a moderate fit and values of > 0.10 showing a poor fitting model (Browne & Cudeck, 1993).

Results

Rasch measurement results

The overall fit statistics for the two subscales, atsuc and usmat, measuring the construct, attitude, were both satisfactory indicating a good fit of the data to the Rasch model. Similarly, the overall fit statistics for the three subscales, comat, anxie, and efmot, measuring the construct, mathematics anxiety, were satisfactory implying a good fit of the data to the Rasch model. Table 1 shows the summary item fit statistics for each scale. The person ability estimates for each of the scales were calculated for further analysis.

Table1
Item fit statistics for all scales

Scale	Infit		Z Std infit		Outfit		Z Std Outfit	
	Person	Item	Person	Item	Person	Item	Person	Item
atsuc	0.99	1.01	-0.10	0.00	1.00	1.00	0.00	0.00
usmat	1.03	1.03	-0.10	0.20	1.01	1.01	-0.10	0.10
comat	0.99	1.02	-0.20	0.10	1.00	1.00	-0.10	0.00
anxie	1.01	1.02	-0.10	0.10	1.01	1.02	-0.10	0.10
efmot	1.02	1.00	-0.10	0.00	1.02	1.02	-0.10	0.20

For the scales used in the study, a higher score means a greater level of construct measured. The anxiety items used in the present study were coded in the same way as in the source. Hence the anxiety item “Mathematics doesn’t scare me at all” was coded 0-5, where 5 indicated a strong agreement with the statement. Because of the nature of the item, however, this coding indicated that a high score indicated that students were actually less anxious about mathematics.

SEM Results

Table 2 provides the correlations among the variables, their means and standard deviations. All correlations between the atsuc variable and the remaining variables including usmat, comat, anxie, and efmot, were statistically significant. Similarly the correlation among the remaining variables was also significant.

The sizes of the correlations among the subscales were moderate, with the largest correlation of 0.76 between the anxie scale and comat scale. The estimates of the path model clearly indicate that the subscales atsuc and usmat accurately measured the construct “attitude towards mathematics”. Similarly the three subscales, comat, anxie and efmot, accurately measured the construct “mathematics anxiety”. The model is shown in Figure 1 with standardised path estimates.

Table 2
Descriptive statistics and correlations among the variables

Measured variables	Mean	SD	atsuc	usmat	comat	anxie	efmot
atsuc	33.79	4.72	1.00				
usmat	37.63	6.98	0.58**	1.00			
comat	34.29	7.39	0.67**	0.65**	1.00		
anxie	32.45	7.65	0.51**	0.56**	0.76**	1.00	
efmot	34.31	6.26	0.55**	0.51**	0.68**	0.59**	1.00

**p < 0.01

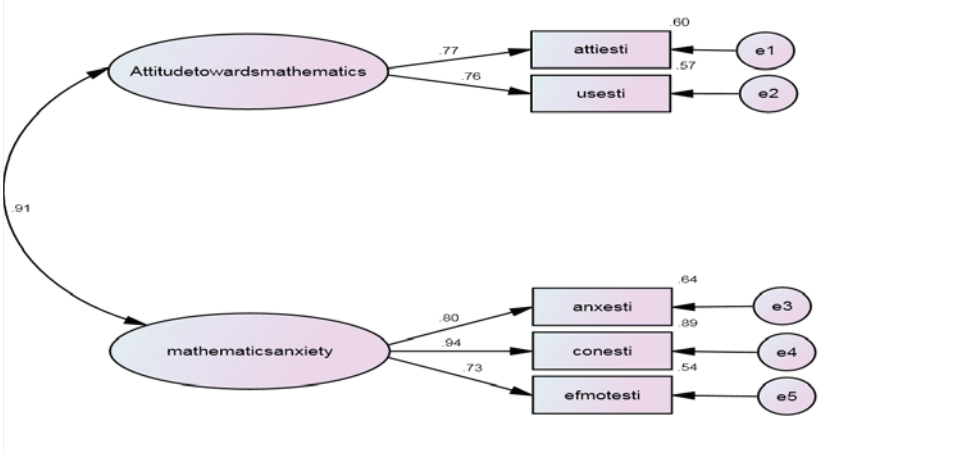

Figure 1. Structural equation model showing the standardised path estimates.

Independent-samples *t*-tests were used to examine whether any gender differences existed among the variables. The results revealed that there was no significant difference between males and females in any of the variables studied. A summary of the results is shown in Table 3. A Bonferroni correction was conducted in order to reduce alpha value inflation due to multiple *t*-tests and to reduce the chances of Type 1 errors. The new alpha value for estimating statistical significance was $p = 0.01$. Using the new alpha value, there was no significant difference between males and females in any of the variables.

Table 3
Results of t-test for gender

Variables	Gender	Mean	SD	*t*(df)	*p*	η^2 (effect size)
atsuc	M	0.63	0.59	-0.779 (109)	0.41	0.006
	F	0.72	0.59			
usmat	M	0.97	0.87	1.600 (109)	0.11	0.023
	F	0.69	0.90			
comat	M	0.69	0.81	1.532 (109)	0.13	0.021
	F	0.42	1.00			
anxie	M	0.42	0.67	1.108 (109)	0.27	0.011
	F	0.24	0.96			
efmot	M	0.39	0.69	-0.023 (109)	0.98	0.000
	F	0.40	0.62			

To test whether there was any significant difference between various age groups in any of the variables, independent-sample test was used. The participants were divided into two groups based on their age as Group 1 (Grade 9) and Group 2 (Grade 11). The independent samples *t*-test results (see Table 4) revealed significant differences between the two groups for the variables attitude towards mathematics and success in maths, confidence in learning mathematics, anxiety and motivation, in favour of older students. No significant difference was observed in usefulness of mathematics scores.

Table 4
Results of t-test for age

Variables	Group	Mean	SD	*t*(df)	*p*	η^2 (effect size)
atsuc	1	0.55	0.53	-2.75 (109)	0.007**	0.065
	2	0.85	0.62			
usmat	1	0.75	0.87	-0.65 (109)	0.52	0.004
	2	0.86	0.92			
comat	1	0.29	0.88	-3.00 (109)	0.003**	0.076
	2	0.81	0.93			
anxie	1	0.10	0.81	-2.93 (109)	0.004**	0.073
	2	0.57	0.85			
efmot	1	0.15	0.52	-4.83 (109)	0.000**	0.214
	2	0.69	0.66			

**$p<0.001$

Discussion

The present study examined the relationship between mathematics anxiety and attitude towards mathematics using structural equation modelling. The findings revealed a positive correlation between the variables, which is not consistent with the previously reported research findings. For example, Durani & Tariq (2009) found a negative correlation between mathematics anxiety and attitude towards mathematics when studying the relationship between the variables in relation to perceptions of undergraduate students' competence at numeracy skills. The participants of the present study were secondary school students from a private school in India. In the current study, however, the coding of the anxiety items, although consistent with previous uses of the items, indicated that a higher score on the anxiety scale related to ease with mathematics, and hence lower anxiety, which may explain the discrepancy.

The findings of the present study also need to be viewed in the relation to the Indian cultural context. In South Indian society education is considered as a necessity. As discussed in the earlier section, extreme competition exists in the education system, with students under pressure to excel in their studies and also to fulfil the expectations and wishes of the family rather than self-interest and personal goals. The findings of the study have to be viewed with great caution by mathematics teachers. For some students a certain level of anxiety can be motivational and stimulating, while the same level of anxiety can have opposite effects on other students. Understanding individual differences in students and the effects of anxiety, teachers have to develop strategies to maintain students' anxiety to a healthy level.

Conclusion

Though mathematics anxiety and attitude towards mathematics have been investigated as separate factors influencing mathematics achievement, there is paucity of literature on the relationship between the variables. This study looked at the relationship between the two constructs among secondary school students in South India. Using structural equation modelling, the study found a positive correlation between mathematics anxiety and attitude towards mathematics.

The limitations of the present study include the difficulty of measuring the constructs attitude towards mathematics and mathematics anxiety with high reliability and validity, although the Rasch estimates did indicate good measurement characteristics. Nevertheless, the study yielded a significant relationship among the variables. The participants in the study were students from one private school in South India so caution needs to be exercised when interpreting the results beyond this context.

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