Mathematics Anxiety in Secondary School Students

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The detrimental consequences of mathematics anxiety have repeatedly been evidenced empirically, yet little is known of its influence on secondary school students in Asia. This study thus examined its origins and impact on 294 secondary students in Singapore through interviews and surveys. Results revealed an average anxiety level of 44% and a negative correlation with achievement. Of the top 5 situations that worried students, 4 were test-related. Nonetheless, highly anxious students continued to persevere and enjoy the subject.

Mathematics anxiety has consistently been proven to be debilitating on mathematics achievement (Foong, 1987; Hembree, 1990; Ma, 1999; Preston, 2008). Research has found it to be a learned behaviour, often arising early in one's educational experience and once it lays roots, its damaging effects will last through the school years.

However, research on Asian students is scarce as the majority of the studies are conducted in the United States (Ho et al., 2000). Moreover, most researchers had worked with high school (10th, 11th, and 12th graders) or college students, rather than those in the lower grades (Wigfield & Meece, 1988). Hence, this study seeks to diagnose how fearful secondary students in Singapore are towards mathematics, to examine its effects on their mathematics performance, and to surface causes for their anxieties.

Furthermore, it is interesting to investigate this phenomenon in Singapore, due to its unique education system and Asian culture. As early as primary 4 (grade 4), students are ability-banded by four subjects, including mathematics and in primary 6, mathematics again contributes to their Primary School Leaving Examination (PSLE) score (maximum aggregate of 300). This will then be used to stream students into the express (EXP), normal academic (NA), or the normal technical (NT) course in secondary schools, where the academically-abled students will enter the express stream. At the end of secondary 2 (grade 8), students are ranked, with double merit given to their mathematics results. Those who excel can then opt to take on advanced subjects or are offered more subjects. At secondary 4 or 5, all students will sit for the national examinations, where again, performance in mathematics will determine their post-secondary education paths.

As such, people in Singapore place great emphasis in academic performance, especially on mathematics. As Ho et al. (2000) noted, this familial and societal stress placed on students in Asian countries may produce a big number of students who are extremely apprehensive about mathematics. Hence, this study is to extend the efforts of researching on mathematics anxiety at this part of the world, and to address three questions.

RQ1. How mathematics-anxious are the students in secondary schools?

RQ2. How significant is the relationship between the mathematics achievement scores and the mathematics anxiety scores of the students?

RQ3. What are some causes of mathematics anxiety in secondary schools' students?

Review of Literature

Relevant research started in the 1970s, with Richardson and Suinn (1972, as cited in Preston, 2008, p. 230) as the first to define it as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations". Since then, others have continued

their efforts driven by research evidence that not only does mathematics anxiety inhibit one's ability to perform mathematically (Preston, 2008) but it is highly probable to have originated from classroom experiences too (Newstead, 1998).

Effects of Mathematics Anxiety on Mathematics Performance

Mathematics anxiety has been continually found to correlate negatively with students' mathematics performance, with correlations ranging from -.11 to -.36 (Ho et al., 2000). Hembree (1990) analysed 151 relevant studies and reported an average correlation of -.34 for school students whereas Ma (1999)'s meta-analysis of 26 studies revealed a correlation of -.27. Similar results were also reported in Asia, like in China, Taiwan, and Singapore.

Chiu and Henry (1990) conducted a study with 562 children from grade 4 to grade 8 and found the correlation between anxiety and performance to be significant and negative. Interestingly, although three rating scales were used, only one was given to the entire sample. Moreover, it was odd that semester grades were not collected from all the students.

In 1987, Foong carried out an exploratory study with 206 secondary four express female students from a single Singapore school. She reported that both mathematics anxiety and test anxiety correlated negatively with mathematics achievement but the relationship between mathematics anxiety and test anxiety were positive and moderately strong. However, her research was conducted more than two decades ago and the instruments were all self-reported Likert-scaled questionnaires that were unable to locate students' sources of anxiety. Hence there exist this pertinent need to assess the mathematics anxiety level in students and its association with mathematical performance.

Causes of Mathematics Anxiety

The most frequently cited cause is the teacher, identified by Foong (1987) as the main source of students' tension. Highly-tensed students dread presenting solutions in front of their classmates, viewing such situations as threatening (Ashcraft, 2002). Teachers who complained of insufficient instructional time might resort to preparing their students for assessment rather than for understanding. This creates more tension when students encounter unconventional problems or when the mathematics becomes more advanced. Researchers also claimed that anxious teachers spend lesser time teaching mathematics and are more likely to pass their phobia to their students (Hembree, 1990; Ma, 1999).

Like teachers, parents could also pass their dread of mathematics to their children (Hembree, 1990). Parents who are overly-concerned about results end up pressurizing their children, more so in Asian countries. Then there exists this myth that mathematical ability is inborn or hereditary (Godbey, 1997). Others believed that females are weaker in mathematics even though researchers (Hembree, 1990; Ho et al., 2000) have found that though females tend to be more anxious, they are not necessarily weaker in mathematics.

Studies on the impact of teaching methods have been inconclusive. Norwood (1994, as cited in Preston, 2008) argued that traditional methods intensified students' anxieties though he found that college students who were weak in mathematics were more at ease with lecture-based teaching. Newstead (1998) claimed that students were more nervous working in groups and Preston added that as most teachers were recipients of direct instruction, they might not enjoy teaching in the constructivist way.

Next, mathematics has being viewed as an inherently difficult subject. Many students are unable to see its practicality and teachers seldom attempt to make the connections. Foong (1987) explained that due to its cumulative and sequential nature, when students missed out something along the way, it is likely that they may never fully comprehend it.

Furthermore, some students have repeatedly performed poorly, leading to loss of self-confidence and increased tension. There are others who believe that mathematics is a measure of their intelligence (Puteh, 2002) and are embarrassed by their inadequate performance. Lastly, student cohesiveness within a class has been found to have a significant positive correlation with mathematics anxiety level (Taylor & Fraser, 2003). The literature review has underlined the multi-faceted and varied nature of the origins of mathematics anxiety, thus supporting the research aim to diagnose our students' anxieties.

Methodology

This study examined the mathematics anxiety of students from a secondary school in Singapore, which offers all the three courses, the EXP stream (PSLE aggregate of 202 - 227), the NA stream (174-194), and the NT stream (117-154).

Samples

294 students from four Secondary Two EXP classes (155) and four Secondary Three EXP classes (139) participated in a survey that rates their mathematics anxiety level. The Secondary Two EXP classes are named as 2E1, 2E2, 2E3, and 2E4, where 2E1 is considered the most academically-inclined class. The same goes for the Secondary Threes, except that for this particular year, 3E1 and 3E2 were matched academically. The Secondary Ones were excluded as their recent transition from primary to secondary level might have added extra stress on them resulting in a higher than usual anxiety level. Furthermore, it was impossible to retrieve their PSLE scores. The Secondary Fours were also not involved as the fourth class had only 18 students. Moreover, it is possible that their anxiety level will be influenced by the year end national examinations.

Six students (students *A* to *F*) were chosen for a face-to-face interview and another six (students *G* to *L*) attempted the interview questions in writing. They were selected from my three classes, a Secondary Three EXP class, a Secondary Four EXP class, and a Secondary Four NA class. Students from the two Secondary Four classes did the questionnaire and were selected based on their scores. All the 12 students chosen had high anxiety levels of more than 55%, falling within the 75th percentile. 10 had failed their mathematics last year, whereas two of them (Secondary Threes, *A* and *G*) did well.

Instruments

Questionnaire. A questionnaire was designed to measure how anxious the students were and to gather reasons for their worrisome thoughts. The three measurement scales used as reference were the Mathematics Anxiety Rating Scale (MARS), the Mathematics Anxiety Scale (MAS), and the Math Anxiety Questionnaire (MAQ), where MARS and MAS are acknowledged to be the most widely-used instruments (Preston, 2008).

MARS, a 98-item instrument created by Richardson and Suinn in 1972, was the first designed to measure mathematics anxiety. It was however not intended for use with school students and its lengthiness made it impractical too. Hence, researchers preferred the 10-item MAS (Godbey, 1997). More recently, Wigfield and Meece (1988) constructed the MAQ that had seven items to measure the emotionality component and four for the cognitive part, which relates to the worrisome nature about having to do well. As advocated by Alexander and Cobb (1984), mathematics anxiety includes the uneasiness felt when sitting for tests or when receiving test scores. As such items were included in MAQ and it was designed for children from grade 6 to grade 12, making it a suitable reference.

The questionnaire was approved by the school's mathematics level head and reviewed by a mathematics professor in the National Institute of Education. Improvements made included the deletion of uncommon situations in secondary schools, like doing long numerical division. Modifications were also made to terminology to make it more appropriate for local use. The final version had 37 items on a 4-point Likert scale, from zero (not anxious) to three (very anxious) and a free-response question to elicit causes of anxiety. The first 16 statements focused on reactions or thoughts about mathematics and the remaining items were mathematics-related tasks where students rate their anxiety level.

Interview. The semi-structured interview was to have an in-depth understanding of the emotions and perceptions held by highly anxious students. Guiding questions were adapted from two master's theses. Johnson (1997) investigated freshmen's mathematics anxiety and examined the potential of a quiz intervention in reducing anxiety, whereas Thjisse (2002) did a case study on five eighth graders put through an intervention programme, to address both their mathematics achievement and mathematics anxiety. In order to ensure that the questions were manageable and the language used was appropriate, a pilot interview was carried out with a Secondary Four EXP student, of moderate anxiety (50th percentile).

Results and Discussion

RQ1. How mathematics-anxious are the students in secondary schools?

Table 1

Distribution of Students' Mathematics Anxiety Level

Mathematics anxiety, MA (%)	No. of Secondary 2 EXP students	No. of Secondary 3 EXP Students	Total no. of students	Percentage of students
$0 < MA \leq 25$	31	14	45	15.3
$25 < MA \leq 50$	67	73	140	47.6
$50 < MA \leq 75$	47	45	92	31.3
$75 < MA \leq 100$	10	7	17	5.78

The survey attained a high response rate of over 85%. The maximum score was 111, and each raw score was represented as a percentage. The mean anxiety level was 43.8%, with the Secondary Threes (45.1%) slightly higher than the Secondary Twos (42.7%). From *table 1*, almost half of the sample was within the 25% to 50% level of anxiety. Although slightly over one-third had more than 50% level of anxiety, it was somewhat relieving to see that only 5.78% falls in the upper quartile. Survey results indicated that mathematics anxiety seem to distress a considerable group of students, thus justifying the need for similar studies in order to bring more awareness to the education fraternity.

Table 2 showed the top five situations that are most stressful for students, where four were related to mathematics tests. Almost 40% indicated that they are very nervous when waiting to receive their marked papers. This also illuminates the test anxiety felt by our students and the undue stress on them to do well in mathematics (Ho et al., 2000).

Table 2

Scores of the Five Items with the Highest Level of Mathematics Anxiety

Rank	Item Description	Mean Score	No. of students who scored 3
1	Waiting to get back my math test paper.	1.966	114
2	If I am absent from school and I miss a math lesson, I worry that I will fall behind.	1.953	90
3	Waiting to get back a math test in which I expect to do well.	1.941	105
4	Being given a "surprised" math test that I was not told about.	1.938	105
5	Thinking about the final math examination in a math class.	1.936	118

RQ2. How significant is the relationship between the mathematics achievement scores and the mathematics anxiety scores of the students?

A moderately strong negative correlation (-0.571) between achievement and anxiety was obtained, using students' previous year, end-of-year mathematics examination results. The Secondary Twos (-0.595) reported a slightly stronger correlation than the Secondary Threes (-0.55). These findings coincided with those from relevant studies, indicating that the highly-anxious students are probably not performing in mathematics.
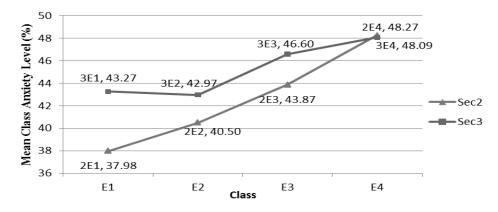

Figure 1. Mathematics anxiety level of each class.

Figure 1 suggested that students in better classes have lower mathematics anxiety level, bearing in mind that 3E1 and 3E2 are matched in academic abilities. Another observation is that the level of anxiety seems to be higher for Secondary Threes rather than Secondary Twos on average. However, more needs to be done to ascertain the relationship between class rankings and the mean class anxiety level.

RQ3. What are some causes of mathematics anxiety in secondary schools' students?

The causes of mathematics anxiety gathered can be placed in the following categories, in decreasing order of intensity: assessments, personal factors, nature and perception of mathematics, negative experiences, learning environment, and parents' effects.

Figure 2. Mathematics anxiety brought about by tests or examinations.

Assessments. This was the most frequently cited reason (34.7% or 179 out of 516) in item 38, and it tallied with the data in *table 2*. Many were nervous during tests and were fearful of performing badly (*Figure 2*). Others were concerned that their academic outcomes will impede their future. *C* shared that whenever she sits for tests, she will keep checking the time and will be perspiring due to nervousness. *E* was bothered by her constant failure and was worried about the national examinations.
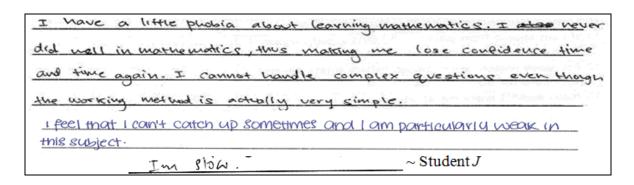

Figure 3. Self-induced mathematics anxiety.

Personal Factors. Mathematics anxiety also stems from within the individual (128) (*Figure 3*). For instance, some wrote that their inability to solve problems troubled them and *F* was vexed that she felt stupid during mathematics lessons. Low self-efficacy is also a factor as these people tense up and give up easily. Others who benchmarked their performance with classmates, like *A*, are constantly concerned about their class ranking.
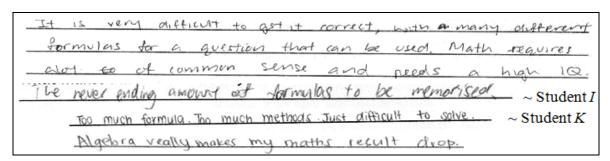

Figure 4. Mathematics anxiety related to the nature of mathematics.

Nature of mathematics. Some 73 students find mathematics very computational and difficult (*Figure 4*). Others are troubled by what is known as abstraction anxiety which stems from more abstract mathematics topics taught in the middle grades (Ferguson, 1986).

A number of students believed that algebra is the root cause of their panicky nature, and they are perplexed by the countless symbols and formulae.

Negative experiences. Constant failure in mathematics strikes fear in some students especially those from the weaker classes (67). When *C* was in primary six, she had many mathematics remediation sessions and often had difficulty completing the heavy load of homework. As a result, she often cried while doing mathematics and frequently fell ill.
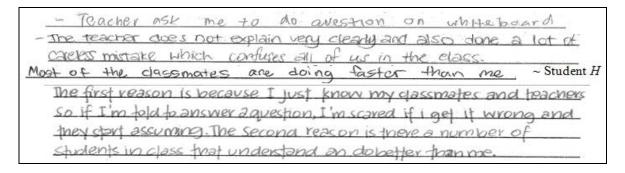

Figure 5. Mathematics anxiety level from teachers, homework and peers

Learning environment. 40 students attributed their fear for mathematics to teachers. Students wrote of teacher actions such as teaching too fast, explaining poorly, or scolding them for doing the questions wrongly. *F* disliked presenting her solutions in class, as she seldom could finish her class work. Homework is an added source of stress (17). *B* admitted that she always copied her classmates' work because she did not know how to do the questions. Seven students wrote that they were hesitant to ask questions as they were worried that their classmates will look down on them (*Figure 5*). *E* felt especially so when the rest seems to have no issue and was afraid of being blamed for wasting class time.

Parents' effects. Only five linked their anxiety to parents. *A* said that his parents wanted him to do well and to enter a junior college, perhaps because he is the only child.

In consolidation, over a third of the causes were test-related where quite a number were obvious symptoms of test anxiety, either physically, like sweating or shaking, cognitively, like negative self-talk, or emotionally which might lead to low self-esteem and hopelessness, the next highest cited category. This finding is consistent with what have been reported on the positive correlation between mathematics anxiety and test anxiety (Ashcraft, 2002; Foong, 1987). It also illuminated the importance that students attached to the necessity to perform well academically. Other reasons like the abstract nature of mathematics and negative prior experiences were in accord with similar studies on anxiety. Although only 40 explicitly mentioned teachers as their source of discomfort, it is undeniable that teacher actions and decisions are intricately linked to other causes.

What was worth mentioning was that it was encouraging to find that all the 12 students interviewed still like mathematics and would continue trying. Most were certain that spending time on mathematics helps to reduce their stress level. *I* commented that it will definitely boost his confidence, *K* replied "Of course! Practice makes perfect!" and *B* said that she will then improve and will not be looked down on by the class.

Conclusion

This study has informed us of the pervasiveness and roots of mathematics anxiety in secondary school students, an area which clearly needs more attention in, especially in

Singapore. Despite limitations like taking samples from a single school and stream or having the mathematics teacher of the students as their interviewer, it nevertheless underlined the predominant factors that interfere with students' mathematics learning, with the majority been school-related. In view of this, the key implication is for teachers to create safe learning environments and to help students develop positive attitudes, since those who are less anxious are more likely to succeed in mathematics.

References

Alexander, L. & Cobb, R. (1984, November). *Identification of the dimensions and predictors of math anxiety among college students*. Paper presented at the annual meeting of the Mid-South Educational Research Association, New Orleans, LA. Retrieved from ERIC database. (ED251320)

Ashcraft, M. H. (2002). Math anxiety: Personal, educational and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181-185.

Chiu, L. & Henry, L. (1990). Development and validation of the mathematics anxiety scale for children. *Measurement & Evaluation in Counselling & Development*, *23*(3), 121-127.

Ferguson, R.D. (1986). Abstraction anxiety: A factor of mathematics anxiety. *Journal for Research in Mathematics Education*, *17*(2), 145-150.

Foong, P. Y. (1987). Anxiety and mathematics performance in female secondary school students in Singapore. *Asia Pacific Journal of Education*, *8*(2), 22-31.

Godbey, C. (1997). *Mathematics anxiety and the underprepared student*. Retrieved from ERIC database. (ED426734)

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33-46.

Ho, H. Z., Senturk, D., Lam, A. G., Zimmer, J. S., Hong, S., Okamoto, Y., Chiu, S. Y., Nakazawa, Y., & Wang, C. P. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education*, *31*(3), 362-379.

Johnson, C.E. (1997). *Attitude or anxiety: Mathematics disposition of high school algebra students*. Unpublished master's thesis, Wichita State University, Kansas.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520-540.

Newstead, K. (1998). Aspects of children's mathematics anxiety. *Educational Studies in Mathematics*, *36*(1), 53-71.

Preston, R. (2008). *Mathematics anxiety: Research and implications for middle school students and teachers*. Conference Proceedings of the Masters in Teaching Program 2006-2008, Olympia, Washington.

Puteh, M. (2002). *Factors associated with mathematics anxiety*. Malaysia : Universiti Pendidikan Sultan Idris.

Taylor, B. A., & Fraser, B. J. (2003, April). *The influence of classroom environment on high school students' mathematics anxiety*. Paper presented at the Annual Meeting of American Educational Research Association, Chicago, IL. Retrieved from ERIC database. (ED476644)

Thijsse, L.J. (2002). *The effects of a structured teaching method on mathematics anxiety and achievement of grade eight learners*. Unpublished master's thesis, University of South Africa, South Africa.

Wigfield, A. & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology*, *80*(2), 210-216.