DO HIGH ABILITY STUDENTS HAVE MATHEMATICS ANXIETY?

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This exploratory study investigates the level of mathematics anxiety among 116 high ability Secondary Two students. These students were from the top 10% of the Secondary Two students in Singapore. Mathematics Anxiety was measured using the Fennema-Sherman Mathematics Anxiety Scale (MAS) (Fennema & Sherman, 1978) which consisted of twelve items which were divided into four categories. The categories were Thinking about Maths, Taking Maths Test, Learning Maths, and Solving Maths Problems. Descriptive statistics on the four categories were reported. The results suggest that Mathematics anxiety did exist among this group of 116 high ability students in two secondary schools. The results also showed that 57 girls in this study exhibited a higher level of Mathematics Anxiety than the 59 boys.

INTRODUCTION

Any researcher investigating the field of anxiety is challenged with a large volume of empirical literature and the diversity of theoretical orientations. In fact, there was some uncertainty whether anxiety was really a separable trait or merely a reflection of some deeper attitude (Wood, 1988). According to Spielberger (1972), "anxiety" is an emotional reaction evoked when one perceives a specific situation as threatening, regardless of whether there is any

present danger. He had also reported a comprehensive range of the more pertinent work in this field. In addition, Spielberger discussed the theory of state and trait anxiety as a conceptual frame of reference to differentiate two related and yet logically very different constructs of anxiety: State Anxiety (A-State) and Trait Anxiety (A-Trait). The concepts of state and trait anxiety have been defined by Spielberger, Gorsuch and Lushene (1970) as follows:

State anxiety (A-State) may be conceptualised as a transitory emotional state or condition of the human organism that is characterised by subjective, consciously perceived feelings of tension and apprehension and heightened autonomic nervous system activity. A-State may vary in intensity and fluctuates over time. (p. 2)

Trait anxiety (A-Trait) refers to relatively stable individual differences in anxiety proneness, that is, to differences between people in the tendency to respond to situations perceived as threatening with elevations in A-State intensity. (p. 2)

For instance, a student who is otherwise not anxious but feels not mathematically competent may develop A-State anxiety when asked to solve a non-standard mathematical problem. Conversely, a student who is high in A-Trait will show strong signs of anxiety whether the problem is mathematical in nature or not. In the academic field, one of the most important types of anxiety traits have been identified: mathematics anxiety (Hembree, 1990).

LITERATURE REVIEW

Anxiety is a critical component and variable in the study of attitudes. From many research studies, it was observed that mathematics anxiety is a subset of mathematics attitudes (Schoenfeld, 1985). However, McLeod (1992) cautioned that the term attitude "does not seem adequate to describe some of the more intense feelings that students exhibit in mathematics classrooms" (p. 576), such as

anxiety, confidence, frustration and satisfaction. In a less intense attitudinal response, mathematics anxiety could also be conceived as a feeling of dislike or fear when one was confronted with mathematics (Foong, 1984). There are an innumerable number of different affective states because of different situational evaluations. Several labels had been utilised to describe anxiety in mathematics, such as "Mathematics Anxiety", "Number Anxiety" and "Mathophobia". More important than the labels are the meanings behind the labels, what each of the term characterises. In the 1970s, Richardson and Suinn (1972) declared that "mathematics anxiety involves 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" (p. 551). Fennema and Sherman (1978) referred to mathematics anxiety as feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics. Tobias and Weissbrod (1980) stated that "the term was used to describe the panic, helplessness, paralysis and mental disorganisation that arises among some people when they are required to solve a mathematics problem" (p. 65). Cemen (1987) also defined mathematics anxiety as a state of anxiety which occurs in response to situations involving mathematics which are perceived as threatening to self-esteem. In her model of mathematics anxiety reaction, she described three antecedents that interacted to produce an anxious reaction with its physiological manifestations such as perspiring and increased heart beat. These antecedents are (1) environmental antecedents – negative mathematics experiences and lack of parental encouragement, (2) dispositional antecedents – negative attitudes and lack of confidence, and (3) situational antecedents – classroom factors and instructional format. Mathematics anxiety is often referred to as "the general lack of comfort that someone might experience when required to perform mathematically" (Wood, 1988, p.11). Mathematics anxiety can take multi-dimensional forms

including for example, dislike (an attitudinal element), worry (a cognitive element) and fear (an emotional element) (Bessant, 1995; Hart, 1989; Wigfield & Meece, 1988). Later, Hembree (1990) broadly defined mathematics anxiety as being in a state of emotion underpinned by traits of fear and dread.

Anxiety is one form of emotions. Hunt (1985) described that the same intense emotions that students who suffer from mathematics anxiety experience as being discomfort characterised by panic, helplessness, paralysis, and mental disorganization when they encountered a mathematical problem. Buxton (1984) identified three emotional states fundamental to mathematics anxiety:

- Irritation can occur from thoughts that do not match one's perception or common sense. Due to the abstract nature of mathematical concepts, many students find them tough to accept unless they can associate to real situations.
- Bewilderment occurs from inability to understand and to make connections.
- Frustration can occur with continuous failure in problem solving when no strategy can surface to attack the problem.

Mathematics anxiety can cause one to forget and lose one's self-confidence (Tobias, 1993). There are many reasons as to why confidence may falter when children learn mathematics. As an example, mathematics anxiety can result when students learn "maths facts" as separate bits of information to be recalled individually. When they forget a "fact" they have no strategy to reconstruct it. Students then lose initiative and confidence (Tay, 2001). Mathematics anxiety usually arises from a lack of self-confidence when working in mathematical tasks. Lack of confidence in oneself is also probably the greatest obstacle to learning because beliefs govern action. Since many mathematics tasks, especially at the secondary (middle) school level are complex, involving multiple-

responses, anxiety can be "over-roused" and debilitating especially among low achievers. They may perceive their inability to handle mathematics problems as "threatening", giving rise to feelings of self-doubt, fear of failure and loss of regard by others. This is commonly observed in the classroom situations when students suffer from mathematics anxiety. They grow to be more self-conscious and self-critical, thinking mostly about their personal and intellectual inadequacy as compared to their classmates. However, as they remain under pressure to solve the problem, they may effect a "face-saving" solution with often a memorized answer or by ignoring relevant information to reduce the complexity of the problem. In extreme arousal, the students may mentally "freeze" and respond in a repetitive and non-adaptive way.

In an earlier study, Carpenter (1980) reported that 21% of the nine-year-olds he studied claimed that doing mathematics made them nervous. A cluster-analytic study was conducted using 157 college students by Jackson and Leffingwell (1999). Three clusters of grade levels in which students first experienced anxiety in their mathematics classes were evident: grade 3 and 4 in elementary level, grade 9, 10 and 11 in high school level and freshman year in college level. Other research studies also indicated that grade four is always the first time the students experience mathematics anxiety (Tankersley, 1993).

RATIONALE OF STUDY

One of the goals of the 1990 Singapore mathematics syllabus was to promote a better attitude towards mathematics: students need to enjoy doing mathematics, to show confidence in using mathematics and to appreciate the beauty and power of mathematics. Achieving these objectives is not an easy task as these goals tend to disagree with each other in practice (Lim, 2002). Even though Singapore is the top performing country at Secondary 2 (13 to 14 year olds) for the TIMSS and TIMSS-R studies, little research is available on

mathematics anxiety by Singapore's Secondary 2 students. In addition, in a recent study by Singapore's Ministry of Education (2000) on a study of pupils' stress, it was found that mathematics was perceived to be the most stressful subject to all Secondary 2 students from all courses. While most teachers believed that high ability students may have few learning problems, it cannot assumed that these students can structure their own learning and just achieve excellent results in their mathematics assessment. This was supported by Stuart (2000) who observed that some students were academically very capable, yet still struggled with mathematics. It is also the experience of the researcher that some high ability students in mathematics perform very well during mathematics lessons and assignment yet fail to perform well during examinations or tests. Most of these students mentioned that during examinations or test, they could not focus as well as when they were in the class. Although some students excel during examinations condition, some just panic. Therefore, it is significant to identify high ability students who experience mathematics anxiety. With the scarcity of local research in this area, the contribution of the present research is significant in providing local data that are pertinent in documenting the mathematics anxiety of Secondary 2 (13 to 14 years old) students in Singapore. In view of this, it is hoped that the research carried out in this study on Singaporean students will contribute significantly towards the professional development of classroom mathematics teachers in Singapore.

RESEARCH QUESTIONS OF STUDY

This study attempted to identify if mathematics anxiety exists in high ability Secondary 2 students. The research questions were:

Question 1 Does mathematics anxiety exists among the high ability Secondary 2 students in Singapore?

Question 2 Which categories of the mathematics anxiety seem most acute for Secondary 2 students'?

Question 3 Do girls show greater mathematics anxiety than boys?

METHOD

Sample

In Singapore, students who pass the Primary School Leaving Examination (PSLE), after six years of primary school, are streamed according to ability. The academically-able students follow a four-year programme either in the Special or the Express stream. Each year, a typical cohort of about 42 000 students will sit for the PSLE; the top 10% of the cohort will be eligible for the Special course in the secondary schools. The Special course is offered to the academically able and linguistically talented pupils. The four-year Special course provides able pupils with the opportunity to study English Language and the Mother Tongue at a higher level and complete their secondary education in four years. At the end of Secondary 4, they take the GCE 'O' level examination. As a result, the research was carried out in four secondary schools with Special course. The high ability students were selected based on their PSLE aggregate T-scores. The sample was representative of the general Secondary 2 Special course population in Singapore schools. A summary of their PSLE mathematics grade were shown in Table 1.

Table 1
Summary of students' PSLE mathematics grade

Grades	A*	A
Frequency	95	21
Percentage	82%	18%

INSTRUMENT

Fennema-Sherman Mathematics Anxiety Scale (MAS)

There are a number of tests available for determining mathematics anxiety. The most commonly used instruments for assessing mathematics anxiety are the Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972), the Fennema-Sherman Mathematics Anxiety Scale (MAS) (Fennema & Sherman, 1978) and the Sandman Anxiety Toward Mathematics Scale (ATM) (Sandman, 1979). The MARS is a 98-item, five-point Likert-format instrument designed to assess mathematics anxiety in a wide variety of specific daily life and academic situations. It provides a measure of anxiety associated with "manipulation of numbers and the use of mathematical concepts" (Richardson & Suinn, 1972). Dew, Galassi, and Galassi (1983) have commented that it has the greatest amount of psychometric reliability and validity data. The MAS, one of nine domain specific scales which make up the Fennema-Sherman Mathematics Attitude Scales, is a 12-item, five-point Likert-format instrument. Fennema and Sherman (1978) defined mathematics anxiety as "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (p. 190). The scale was validated on US secondary school students. The ATM, one of the subscales of the Sandman Mathematics Attitude Inventory, is a 6-item, four-point Likert format instrument. The instrument was developed for Year 8 to Year 11 students. Since Secondary 2 students

were involved in this study, the MAS and ATM seemed to be more appropriate as they were originally designed for use with students in the high school age groups. The MARS is too time consuming for our purpose – having 98 items (compared to 12 and 6 items in the MAS and ATM respectively). Moreover, too many items may cause survey fatigue and this may cause Secondary 2 students not to be focused in responding to the items. Furthermore, Dew, Galassi, and Galassi (1983), in their study of a sample of 769 undergraduates found that the MAS and the ATM were significantly and strongly correlated ($r = 0.78$, $p < 0.001$) to each other compared with the MARS. The MAS-MARS correlation was 0.68 and the ATM-MARS was 0.67. These figures give some indication that the ATM and MAS are measuring the same construct. For the present investigation, a pilot study was carried out to provide some indication of the reliabilities of the MAS for a sample of Singapore Secondary 2 students. Results of the responses of 70 Secondary 2 students to the MAS were used to compute the reliabilities of the instruments. Comparison of the values of the mean of the MAS in the pilot study with Singapore's studies of Foong (1984), Tan (1990) and Lenden-Hitchcock (1994) showed a slightly higher level of mathematics anxiety in the pilot sample. The differences of the mean scores were, however, very small and had not been tested statistically. The reliability using Cronbach's alpha for the pilot sample was 0.75. The Fennema-Sherman Mathematics Anxiety Scale (MAS) was specifically designed for secondary school students and had a high reliability in the pilot sample. Furthermore, it had been used in Singapore by three researchers (Foong, 1984; Tan, 1990; Lenden-Hitchcock, 1994). It was thus decided that Fennema-Sherman Mathematics Anxiety Scale (MAS) would be the instrument adopted for assessing mathematics anxiety in the study design. For the purpose of the study, the scores were modified to range 1 (strongly agree) to 5 (strongly disagree) instead of the other way. Half the items were positively worded, while the other half

was negatively worded. Scoring of negatively worded items was reversed so that a higher score would indicate higher mathematics anxiety. A high total score in the scale would reflect a high level of reported mathematics anxiety whereas a low total score would mean a low level of reported mathematics anxiety. The Fennema-Sherman Mathematics Anxiety Scale (MAS) comprises 12 items under four categories: Thinking about Maths (4 items), Taking Maths Test (3 items), Learning Maths Lesson (2 items), and Solving Maths Problem (3 Items).

PROCEDURE

In the administration of the MAS, the teachers referred to the MAS as the Mathematics Attitudes Scale as printed on the form and "anxiety" was avoided. The mathematics teachers were not present in class during the survey. The students were given enough time to respond to all the items. Though no time limit was set, the students completed the the questionnaires within 15 minutes. As the instructions and statements were clear, no oral questions were asked during the course of the administration of the questionnaire.

RESULTS AND DISCUSSION

The descriptive statistics are reported in Table 2. High means indicate high levels of mathematics anxiety. These high-ability Secondary 2 students appear to show a high level of test anxiety, with the top two means in the list belonging to the 'Taking Maths Test' category. The item in the third place is the 'Solving Maths Problem' category where the student were worried if they were able to solve maths problem. Items in the 'Learning Maths' and 'Thinking About Maths' had medium to low means. This is expected of mathematically able students

Table 2
Items arranged in Descending Order by Means

Items	Mean	Standard Deviation	Thinking about Math	Taking Maths Test	Learning Maths Problem	Solving Maths
I am usually at ease during maths tests.	3.30	1.23		√		
A maths test would scare me.	3.18	1.20		√		
I do not usually worry about being able to solve maths problems.	3.13	1.21				√
I seldom panic during a maths test.	3.13	1.24		√		
Maths does not scare me at all	3.07	1.32	√			
I get a sinking feeling when I think of trying difficult maths problems	2.90	1.26				√
It would not bother me at all to take more maths courses	2.88	1.24			√	
Mathematics usually makes me feel uncomfortable and nervous	2.74	1.18	√			
My mind goes blank and I am unable to think clearly when working mathematics.	2.69	1.25				√
Mathematics makes me feel uncomfortable, restless, irritable and impatient.	2.63	1.23	√			
Mathematics makes me feel uneasy and confused.	2.57	1.14	√			
I am usually at ease in maths lessons.	2.24	1.04			√	

The responses on the Likert scale to the 'Taking Maths Test' and 'Solving Maths Problem' categories are tabulated in Table 3 and Table 4 respectively.

Table 3
Responses in the 'Taking Maths Test' Category (%)

Item	Strongly Agree	Agree	Unde-cided	Disagree	Strongly Disagree
I am usually at ease during maths tests.	6.0	27.6	15.5	31.9	19.0
A maths test would scare me.	16.4	24.1	29.3	21.6	8.6
I seldom panic during a maths test.	6.9	32.8	18.1	25.0	17.2

It was found in Table 3 about half of the students showed great anxiety for the Maths Test. They were panic of their own unpreparedness in sitting for a test. Whether or not they were well prepared for the test, their mind set them into a "fear mode." Being in the top 10% of the cohort has probably pressured them to perform well.

Table 4
Responses in the 'Solving Maths Problem' Category (%)

Item	Strongly Agree	Agree	Unde-cided	Disagree	Strongly Disagree
I do not usually worry about being able to solve maths problems.	8.6	25.9	25.0	25.0	15.5
I get a sinking feeling when I think of trying difficult maths problems	13.8	19.0	24.1	29.3	13.8
My mind goes blank and I am unable to think clearly when working mathematics.	11.2	16.4	19.0	37.1	16.4

In the "Solving Maths Problem' category (see Table 4), more than one third of the students indicated that they were worry about being able to solve maths problems. Teachers should identify these students who had high anxiety when solving maths problems.

The following tables compare the mean responses of boys and girls in the four categories. In all the four categories, the girls appeared to be more anxious than the boys. This finding seems to be consistent to the common perception that girls tend to report higher levels of mathematics anxiety (Felson & Trudeau, 1991).

Table 5
Items in the 'Taking Maths Test' Category

	Boys		Girls	
	Mean	SD	Mean	SD
I am usually at ease during maths tests.	2.88	1.15	3.74	1.17
A maths test would scare me.	2.59	1.05	3.79	1.03
I seldom panic during a maths test.	2.75	1.11	3.53	1.26

In the 'Taking Maths Test' category, all the students appeared to show relatively high levels of anxiety, where the lowest mean is 2.59 for the boys who felt maths test would scare them. The highest mean is 3.79 for the girls who indicated that maths test would scare them. The boys seemed to handle challenges and tests better than girls.

Table 6 showed that the girls were more anxious than the boys in solving maths problems. Their mathematics teachers should provide problem-solving strategies for the girls, as the high level of anxiety reflects a lack of confidence.

Table 6
Items in the 'Solving Maths Problem' Category

	Boys		Girls	
	Mean	SD	Mean	SD
I do not usually worry about being able to solve maths problems.	2.86	1.18	3.40	1.19
I get a sinking feeling when I think of trying difficult maths problems	2.59	1.19	3.21	1.26
My mind goes blank and I am unable to think clearly when working mathematics.	2.34	1.18	3.05	1.22

Table 7
Items in the 'Learning Maths' Category

	Boys		Girls	
	Mean	SD	Mean	SD
It would not bother me at all to take more maths courses.	2.56	1.16	3.21	1.24
I am usually at ease in maths lessons.	1.97	0.83	2.53	1.17

Table 7 shows that the boys were less anxious than the girls in 'Learning Maths' category. The results in Table 7 suggested that learning mathematics was not seen as stressful for these boys. It appears that boys tend to take things more easily as compare to girls.

Table 8
Items in the 'Thinking About Maths' Category

	Boys		Girls	
	Mean	SD	Mean	SD
Maths does not scare me at all	2.58	1.26	3.58	1.19
Mathematics usually makes me feel uncomfortable and nervous	2.42	1.09	3.07	1.19
Mathematics makes me feel uncomfortable, restless, irritable and impatient.	2.32	1.17	2.95	1.22
Mathematics makes me feel uneasy and confused.	2.24	1.07	2.91	1.12

The results in Table 8 show that 'Thinking About Maths' category was not as stressful for these students. However, the girls continued to be scared about mathematics.

CONCLUSION

In conclusion, mathematics anxiety does exist among this group of 116 high ability Secondary 2 students in Singapore. Their fear of taking mathematics test and solving mathematics problem was greater than their fear in learning mathematics and thinking about mathematics. Furthermore, the girls show greater mathematics anxiety than boys.

Although the exploratory study was conducted using a small number of items and for only 10% of the Secondary 2 students in Singapore, several implications could be made. As the size of the sample is small (116 respondents), this result may not be generalized to a bigger population. More researches of this kind can be done in future using bigger samples involving different groups of students. This research should also be replicated to compare the level of mathematics anxiety among students in other types of schools.

Teachers should think of ways to overcome or at least prevent mathematics anxiety especially among high ability students. The results suggest that teachers can help to build a positive and encouraging classroom environment, and can stress on understanding and thinking processes rather than on memorizing the process involved. They should also use concrete teaching aids and reduce tension during mathematics classes. Moreover, it looks like teachers have a major role to play to help their students overcome mathematics anxiety.

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