SCIENCE ANXIETY AMONG FORM FOUR STUDENTS IN PENANG: A GENDER COMPARISON

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This paper reports a causal-comparative study of science anxiety among Form Four students in Penang. The Wynstra's (1991) Science Anxiety Inventory (SAI), which consists of six factors (i.e., danger anxiety, science test anxiety, math and problem-solving anxiety, squeamish anxiety, performance anxiety, and science classroom anxiety), was translated and modified to gauge the levels of science anxiety. Selected through a stratified random sampling, the sample comprises 160 students with equal number of males and females. Student ratings in Modified SAI were quantitatively analysed by gender using unpaired samples t-test with significance level set at probability level of 0.05. The findings indicate that Form Four females generally rated their overall science anxiety appreciably higher than did Form Four males. While there was no statistical significant difference between the ratings of males and females on science classroom anxiety, females rated appreciably higher than did males across five other subscales. These findings are discussed and implications for educational practice in the context of science learning in Malaysian classrooms are proffered.

Introduction

There have been continuous concerted efforts by the various divisions in the Malaysian Ministry of Education to encourage more students to opt for science-based subjects. This aspiration is not idiosyncratic to Malaysia. Many other countries like the United Kingdom and the United States also aspire to increase the uptake of science among their secondary or high school students. Globally, it can be observed that not only are more science-based students expected to graduate from secondary schools and higher institutions, there is also a proportionately higher demand for female science students as societies become more responsive to women pursuing science careers.

Malicky (2003) reported that, while women were over-represented in some fields such as psychology, they were still under-represented in the fields of science and engineering. He argues that such a shortfall of women in the fields of science, mathematics and engineering (SME) has at least two implications for productivity. Firstly, women represent an untapped reservoir of potential employees, and second, they may bring new perspectives and ideas to meeting new challenges. Malicky's (2003) argument seemed to support the theorization of Barrow, Holden, Bitner, Kane, and Nichols (1986) that, by not enrolling in science courses, these girls (or women) have disqualified themselves for many careers, effectively keeping them in traditional roles.

Among many factors proposed to explain low enrolment in science and mathematics was the interaction between emotions and learning. Since the early 1980's, theoretical and practical advances have been made in correlating students' feelings, particularly science anxiety, with their ability to understand the subject matter as well as their career choices (Mallow, 1994, 1998). Research has suggested that science anxiety does exist in many students as well as in society in general (Mallow, 1981; Pratt, 1981). Mallow (1981) purported that this fear could result in students becoming frustrated, denying competence in science, and ultimately disliking and avoiding anything scientific. Many students, especially females, perceived science as beyond the abilities of the average person. This type of negative attitude was a serious hurdle and may be debilitating to the point that students were unable to perform well in any of their courses. It might even affect performances in courses in which students had previously achieved success (Anderson & Clawson, 1992).

Accordingly, it is worthwhile to investigate the nature of differences between the science anxiety of boys and girls in Malaysia. Subsequently, quest for ways to reduce students' anxiety can then be embarked upon, as factors in science anxiety can then provide clues that can be worked with to increase interest and to motivate students to participate in the field of science. This is particularly useful to Malaysian science educators in their efforts to help address the under-representation of females in science-related careers.

Science Anxiety

The phenomenon of fear and avoidance of learning science has been generally labelled as science anxiety. Mallow (1981) defined science anxiety as the general fear or aversion by students and society towards science concepts, scientists, and science-related activities as a whole. His extensive research on science anxiety and its effects on student learning was well documented in his book, *Science Anxiety: Fear of science and how to overcome it.* Together with Sharon Greenburg, he carried out pioneering work with students who identified themselves as being science anxious and established a science anxiety clinic in 1997 (Mallow & Greenburg, 1983). They theorised that science anxiety resulted from intervening self-messages rather than from the science learning itself. Messages such as "girls aren't expected to do well in science" created the sex-role stereotyping which established a dichotomy between success in learning science and femininity. At schools, when girls reached the age of adolescence, this message was frequently reinforced by peer pressure to avoid outperforming boys or appearing to be "brainy". Girls who have previously enjoyed and succeeded in science learning often succumb to choosing popularity if they accept the two as mutually exclusive (Mallow & Greenburg, 1983).

Meanwhile, Shodahl and Diers (1984) reckoned that science anxiety was a problem related to mathematics anxiety. Wynstra (1991), however, argued that science anxiety was much more complex than mathematics anxiety, and that it (science anxiety) involves a mathematics anxiety component since science, especially physical sciences, involved the use of mathematics and problem solving. Wynstra (1991) reasoned that science anxiety and mathematics anxiety included a test anxiety component since tests were generally given in science and mathematics classes. In addition, there were some unique components in science anxiety, including anxiety over the parts of science that could make one squeamish, anxiety over performing and communicating in science class, anxiety about being in class and doing the classroom work, and anxiety about working with mechanical equipment.

Accordingly, the Science Anxiety Inventory (SAI) was developed by Wynstra (1991). The original SAI comprised forty-nine items designed to measure high school students' level of anxiety towards science related activities. All the items were Likert-scaled, ranging from one through five in the form of a questionnaire. Responses range from "not at all nervous" at the beginning of the scale to "very nervous" at the end of the scale. Since there were no negative statements in the inventory, a high score on the SAI would be indicative of a high level of science anxiety.

Psychometrically evaluated by Wynstra (1991), SAI was found to be a reliable and valid instrument to measure science anxiety. Using the Pearson Product-Moment Correlation technique, the test-retest reliability of the SAI was measured at +0.92. The overall internal reliability, established using Cronbach's coefficient alpha, was measured at 0.94, which can be claimed to be a high value and indicating that the items had high internal consistency. The content of the SAI was validated by having four science teachers, one from each field of science – Chemistry, Physics, Biology, and Earth Science – examine the questionnaire. Construct validity, which was established by performing a factor analysis, yielded six interpretable factors, namely (1) danger anxiety, (2) science test anxiety, (3) math and problem-solving anxiety, (4) squeamish anxiety, (5) performance anxiety, and (6) science classroom anxiety. Table 1 provides a description for each of the factors.

Table 1
Description of Six Factors in Wynstra's (1991) Student Anxiety Inventory

No	Factor	Description
1	Danger Anxiety	Anxiety over doing things in science class that might be dangerous, such as using poisonous or flammable chemicals, lighting a Bunsen burner, or watching a demonstration that explodes and makes loud noise.
2	Test Anxiety	Anxiety over taking tests, final examinations, laboratory tests, and answering different kinds of test questions.
3	Math and Problem Solving Anxiety	Anxiety over math and problem solving in science which include activities such as working out problems, and interpreting graphs and tables.
4	Squeamish Anxiety	Anxiety pertaining to activities that could make one squeamish, such as dissecting a cockroach, looking at a preserved specimen in a bottle, or pricking one's finger for blood typing experiments.
5	Performance Anxiety	Anxiety over carrying out science projects and explaining the results to the class, being asked a question in class, or having the teacher to watch the student perform a laboratory procedure.
6	Science Classroom Anxiety	Anxiety arises in the science classroom, such as while taking notes, listening to a lecture, and answering questions for a homework assignment.

Gender and Class Level Differences in Science Anxiety

Gender has often been associated with science anxiety, the common assumption being that females were more anxious about science than males. Two thirds of the enrollees in The Science Anxiety Clinic, founded by Mallow (1978) to alleviate such anxiety or fear, were females. Udo, Ramsey, and Mallow (2004) argued that science anxiety acted as a career filter, preventing science anxious students from enrolling in certain science-related fields. While the number of women majoring in science has increased dramatically over the past two and a half decades, females were more science anxious than males particularly in physics (Udo, Ramsey, Reynolds-Alpert, & Mallow, 2001). This gave credence to the finding of the American Institute of Physics [AIP] (2000) that reported the relatively low proportion of females choosing to major in physics as compared to other subjects and that such phenomenon has not significantly changed in the past decade.

Chiarelott and Czerniak (1987) developed the Czerniak Assessment of Science Anxiety (CASA) questionnaire for use in their study of fourth through ninth graders (ages 9-14). The questionnaire comprises 40 statements, all of which were science related, to test four areas (dimensions), namely (a) testing situations, (b) laboratory/experiment situations, (c) classroom/lecture situations, and (d) science-related situations. Participants responded by checking how nervous they would feel if they were asked to perform that activity at that moment, using a five-point scale that ranges from "very calm" to "very nervous". The results indicated that females had higher levels of science anxiety on three dimensions of the CASA: testing, laboratory/experiment (e.g., performance in front of others) and science-related (e.g., direct application of scientific principles) situations. Chiarelott and Czerniak (1987) concluded that science anxiety started as soon as children began to learn science: Age 8 or lower in the U.S. However, anxiety did not increase with grade level from grade four through nine. By ninth grade, significantly different levels of science anxiety were evident among males and females. This phenomenon of greater science anxiety among females was not idiosyncratic or unique to the United States (Beyer, 1991; Mallow, 1993, 1994; Whitten, Foster, & Duncombe, 2003). For example, Tobias, Urry, and Venkatesan (2002) reported a "chilly climate" for females in Denmark science classes.

Rohana (1995) conducted a study using the modified version of the Wynstra's (1991) Science Anxiety Inventory (SAI) and found significant differences in science anxiety amongst Form One, Form Two, and Form Three students in Malayisa. When a comparison was made by grade level, Form Two students were the most science anxious followed by Form Three and Form One students. Form Two students were also found to be consistently the most anxious in five of the six factors in SAI, namely science test anxiety, math and problem solving anxiety, squeamish anxiety, performance anxiety, and science classroom anxiety followed by Form One and Form Three students. On the other hand, Form One students reported significantly higher danger anxiety than students at other grade levels and this could be attributed to the fact that they were inexperienced with the laboratory equipment.

Results obtained by Rohana (1995) did not support the results obtained by Meissner (1988). Using the Science State-Trait Anxiety Inventory (STAI) to measure the science anxiety in fourth, sixth, eighth, tenth, and twelfth graders, Meissner (1988) found no obvious trend of science anxiety with grade levels. While science anxiety was present at all grades, there was no particular level where more significant science anxiety was identified.

Purpose and Significance of the Study

This study aimed to compare the differences between the perceptions of Form Four male and female students in urban schools of Penang on science anxiety as a whole and on each of the six factors of the SAI (i.e., danger anxiety, science test anxiety, math and problem-solving anxiety, squeamish anxiety, performance anxiety, and science classroom anxiety).

The understanding of gender difference in science anxiety will help educators to target curriculum revisions at specific groups, such as females, that might have high levels of science anxiety. Further understanding of the differences between genders in the factors that contribute to science anxiety will yield valuable information that can be tapped on by teachers in identifying effective strategies to overcome problems pertaining to each of these factors related to science anxiety. Additionally, the findings of this study can serve as a basis to further explore the causes of science anxiety and for developing programmes aimed at decreasing the level of science anxiety amongst secondary school students. Such effort is deemed necessary in view of the current endeavour of the Malaysian Ministry of Education to meet the targeted 60:40 ratio of science versus non-science students by 2010.

Research Questions

This study examined the following research questions:

1. Is there a statistically significant difference between the science anxiety of Form Four male and female students in urban schools of Penang as measured by the Malay version of modified Wynstra's (1991) Science Anxiety Inventory (SAI)?
2. Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the following factors of science anxiety:

a. Danger Anxiety?

b. Science Test Anxiety?

c. Math and Problem Solving Anxiety?

d. Squeamish Anxiety?

e. Performance Anxiety?

f. Science Classroom Anxiety?

Methodology

Research Design

Given the research questions that aimed to establish the differences between Form Four male and female students' perceptions on science anxiety and on each of the six factors of science anxiety under conditions where experimental manipulation was impossible, a causal-comparative design was deemed appropriate. According to Borg and Gall (1989; p.537), "the causal-comparative method is aimed at the discovery of possible causes and effects of a behaviour pattern or personal characteristics by comparing subjects in whom this pattern or characteristic is absent or present to a lesser degree".

Sample

The sample, consisting of 160 Form Four students, was drawn from four urban schools in Penang using a stratified random sampling technique. These four schools (one all-girls school, one all-boys school, and two co-educational schools) were randomly selected through a ballot from a total of thirty urban schools. Using the table of random numbers, an equal number of girls and boys were sampled from the four schools given that the aim of this study was to compare gender differences in science anxiety. Of the total number of participants in this study, 33.75% were science majors (e.g., students who opted for more than one of the science subjects that may include Physics, Chemistry, Biology, and Basic Engineering), whereas the others were non-science majors (e.g., students who chose only Science as a single general science subject).

Instrumentation

The modified version of Wynstra's (1991) Science Anxiety Inventory (SAI) was used because it was psychometrically sound with six distinct interpretable factors and had been modified for local research. In this modified SAI, Rohana (1995) discarded 11 items out of the original 49 items of the SAI, leaving only 38 items. While 49 items did amalgamate into six factors, 11 items were excluded on the basis of low factor loadings which were less than 0.5 when data were subjected to factor analysis. This, according to Wynstra (1991), allowed for "clearer interpretation of the factors" (p.133).

The content of the modified SAI was validated by three experienced science educators who proposed some slight modifications to three items in order to suit them to the Malaysian context. For instance, the item on "collecting saliva to examine with a microscope" was changed to "collecting cheek cells to examine with a microscope". Pearson Product-Moment Correlation for one-month test-retest reliability using a sample of 45 Forms 1-3 students was found to be high at +.97. Employing similar test-retest procedure over two-week duration on 30 Form 4 students, a correlation coefficient of +.92 was obtained. Furthermore, construct validity for each of the six factors was supported by means of factor analysis (Rohana, 1995).

Data Collection Procedures

Approval was sought and obtained, in hierarchical order, from (i) the Educational Planning and Research Division (EPRD), Malaysian Ministry of Education, and (ii) the Penang State Education Department, and (iii) the four randomly selected secondary schools.

Subsequently, arrangements were made with the senior assistant of each school for name lists of students, suitable date, time, and place to administer the Modified SAI. The first author personally administered the Modified SAI according to the arranged schedule and under a standardised whole class setting. Participating students were informed of the purpose of the study and that their responses would be kept confidential. The students were told that the Modified SAI was not a test and hence, there were no correct or incorrect answers. It was the students' honest views and responses that mattered most.

Data Analysis Procedures

A t-test for unpaired samples was used as the primary statistical analysis tool. In addition to the independent t-test, effect size (ES) was calculated "as an aid to interpreting the results of a single study" and "for assessing the practical or educational significance of relationships and group differences" (Borg & Gall, 1989, pp.363-364). Mathematically, the effect size in this study was computed by subtracting the mean of the males from the mean of the females and dividing by the standard deviation of the males. The rule of thumb by Cohen (1988) in interpreting the practical importance of ES in education, or educational significance, was provided as follows:

- small effect $0.2 \leq ES < 0.5$
- medium effect $0.5 \leq ES < 0.8$
- large effect $0.8 \leq ES$

These values have no absolute meaning and are only relative to typical findings in education and behavioural sciences.

Results

Using the SYSTAT programme, a t-test for unpaired samples was carried out. The results of the data analyses are presented in Table 2 followed by a discussion addressing each of the research questions (RQ).

Table 2
Average Item Mean, Average Item Standard Deviation and T-test for Unpaired Samples Between Male (N=80) and Female (N=80) Scores on Overall and Each Factor of the Malay version of modified Wynstra's (1991) Science Anxiety Inventory (SAI)

Factor	Males		Females				
	Mean	SD	Mean	SD	t	p	ES
Overall	69.88	18.23	79.85	16.46	3.63	<.001	+0.55
Danger Anxiety	17.15	5.54	19.74	6.51	2.71	.008	+0.47
Science Test Anxiety	17.95	5.90	20.34	5.31	2.69	.008	+0.41
Math and Problem Solving Anxiety	10.58	3.49	11.99	5.09	2.05	.043	+0.40
Squeamish Anxiety	10.68	4.06	12.83	4.12	3.33	.001	+0.53
Performance Anxiety	9.65	2.84	11.24	3.56	3.12	.002	+0.56
Science Classroom Anxiety	3.88	1.39	3.73	1.04	0.77	.441	-0.11

RQ(1): Is there a statistically significant difference between the science anxiety of Form Four male and female students in urban schools of Penang as measured by the Malay version of modified Wynstra's (1991) Science Anxiety Inventory (SAI)?

As shown in Table 2, the t-test for unpaired samples yielded a t of 3.63 which was statistically significant ($p < .001$) and a "medium" (Cohen, 1988) effect size of +0.55 that was educationally significant. The mean obtained for the females (79.85) was statistically significantly higher than the mean obtained for the males (69.88). A high science anxiety score denotes a high degree of science anxiety. Therefore, the Form Four females show an appreciably higher degree of science anxiety than males.

RQ(2a): Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the Danger Anxiety?

As shown in Table 2, the t-test for unpaired samples for Danger Anxiety yielded a t of 2.71 which was statistically significant ($p = .008$) and a "medium" (Cohen, 1988) effect size of +0.47 that was educationally significant. The mean obtained for the females (19.74) was statistically significantly higher than the mean obtained for the males (17.15). Therefore, the Form Four females show a markedly higher degree of danger anxiety than males.

RQ(2b): Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the Science Test Anxiety?

As shown in Table 2, the t-test on Science Test Anxiety for unpaired samples yielded a t of 2.69 which was statistically significant ($p = .008$) and a "medium" (Cohen, 1988) effect size of +0.41 that was educationally significant. The mean obtained for the females (20.34) was statistically significantly higher than the mean obtained for the males (17.95). Therefore, the Form Four females show a markedly higher degree of science test anxiety than males.

RQ(2c): Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the Math and Problem Solving Anxiety?

As shown in Table 2, the t-test on Math and Problem Solving Anxiety for unpaired samples yielded a t of 2.05 which was statistically significant (p = .043) and a "medium" (Cohen, 1988) effect size of +0.40 that was educationally significant. The mean obtained for the females (11.99) was statistically significantly higher than the mean obtained for the males (10.58). Therefore, the Form Four females show a markedly higher degree of math and problem solving anxiety than males.

RQ(2d): Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the Squeamish Anxiety?

As shown in Table 2, the t-test on Squeamish Anxiety for unpaired samples yielded a t of 3.33 which was statistically significant (p = .001) and a "medium" (Cohen, 1988) effect size of +0.53 that was educationally significant. The mean obtained for the females (12.83) was statistically significantly higher than the mean obtained for the males (10.68). Therefore, the Form Four females show a markedly higher degree of squeamish anxiety than males.

RQ(2e): Is there a statistically significant difference between the Form Four male and female students in urban schools of Penang on the Performance Anxiety?

As shown in Table 2, the t-test on Performance Anxiety for unpaired samples yielded a t of 3.12 which was statistically significant (p = .002) and a "medium" (Cohen, 1988) effect size of +0.56 that was educationally significant. The mean obtained for the females (11.24) was statistically significantly higher than the mean obtained for the males (9.65). Therefore, the Form Four females showed a markedly higher degree of performance anxiety than males.

RQ(2f): Is there a statistically significant difference e between the Form Four male and female students in urban schools of Penang on Science Classroom Anxiety?

As shown in Table 2, the t-test on Science Classroom Anxiety for unpaired samples yielded a t of 0.77 that was not statistically significant (p = .441). The effect size of -0.11 was considered to be of no educational significance (Cohen, 1988). The mean obtained for the males (3.88) was not statistically significantly higher than the mean obtained for the females (3.73). Therefore, the Form Four males and females do not show a markedly difference in the degree of science classroom anxiety.

Discussions

In relation to the overall science anxiety, the results indicated that Form Four girls have higher levels of science anxiety compared to the boys. The overall science anxiety outcome in this study is consistent with earlier findings by Wynstra (1991) and Meissner (1988). The results from Wynstra (1991) study indicated that high school females had more science anxiety than males. Equally, Meissner (1988) reported a significantly higher science anxiety among female students of grades four, six, eight, ten, and twelve.

The higher anxiety level noticed in the females can be partly explained by the pressures the society exerts on females who opt to study science in a "male-dominated" society in which science is seen as masculine (Jegede & Okebukola, 1988). Additionally, sex role stereotyping whereby males are often regarded as active individuals and females as passive onlookers may have led females to believe that they are not as smart as men, thus making them more anxious when studying science. Such barriers related to gender role stereotyping was observed in Indonesia, Malaysia and Myanmar where science and mathematics educators who responded in a research study (SEAMEO RECSAM, 2005) expressed their belief that gender role stereotyping affected career preferences of women. They argued that women's main duty was to look after the welfare of their family. The respondents also indicated that in order for career women to succeed, they must strike a balance between home and work.

The results in which the female students obtained a significantly higher mean in danger anxiety score than did the males suggest that the former were more apprehensive when performing activities in the science classes that might be dangerous, such as using poisonous or flammable chemicals, lighting a Bunsen burner, or handling explosive substances. Wynstra (1991) reported similar finding for this factor in the SAI. This finding may be explained by the traditional stereotypes of male and female sex roles. While girls were associated with conformity, passivity, and domestic activity, boys were encouraged to be adventurous and innovative. Boys on the other hand were expected to get into trouble and get themselves out of it. Girls were more protected compared to boys (Kelly, 1987). Therefore, when performing activities that might be dangerous, girls tend to react with a higher degree of anxiety than their male counterparts.

In relation to science test anxiety, the finding of this study suggests that girls were more anxious over taking tests, sitting for final examinations, answering different types of test questions, and carrying out laboratory tests compared to their male counterparts. Similar findings were also reported by Wynstra (1991) for this factor in the SAI. This finding can be explained by the sex-role stereotyping (e.g., "girls aren't supposed to do well in science") which establishes a dichotomy between success in learning and femininity (Mallow, 1981). Many people begin to develop expectations of success and failure and the self-fulfilling prophecy begins to operate. Due to negative labelling, female students may develop expectations of failure in science, frequently followed by actual failure experiences that serve to validate their expectations. Therefore, this problem of science test anxiety manifests in the students as a self-defeating cycle. Interestingly, the research conducted by SEAMEO RECSAM (2005) found that even though female respondents disagreed with the view that science and mathematics were valuable subjects only for boys, they tend to agree that they needed to work harder than boys to get the same results in science and mathematics.

In relation to mathematics and problem solving anxiety, the results suggest that girls were more fearful than boys when faced with tasks that require mathematics and problem solving skills, such as working out problems, and interpreting graphs and data tables. This finding also agrees with the results obtained by Wynstra (1991) on the same factor in the SAI. One of the myths about mathematics identified by Kogelman and Warren (1978) was that men were naturally better than women. Teachers who subscribed to such view may convey this hidden gender-bias message of mathematics and problem solving as a "male" field, thus eroding and impairing the female students' confidence and further creating a self-fulfilling prophecy of their incompetence in mathematics and problem solving.

In relation to squeamish anxiety, the results suggest that females were more nervous than males when performing activities that could make them squeamish, such as dissecting a cockroach, looking at a preserved specimen in a bottle, or pricking one's finger for blood typing experiments. Wynstra (1991) also found a statistically significant difference ($p < .05$) with females scoring higher than males on this factor in the SAI. This finding may be explained by the adventurous and innovative nature of boys which render them less anxious about performing activities that could make them squeamish compared to girls. The squeamish anxiety amongst girls may intensify when they encounter female science teachers who model discomfort and uneasiness when performing squeamish activities.

In relation to performance anxiety, the results indicate that female students were more anxious than male students over their performance in the science class or the science laboratory, such as carrying out science projects and explaining the results to the class, being asked a question in class, or having the teacher watch them perform a laboratory procedure. Wynstra (1991) also reported statistically significant difference in the mean performance scores with females scoring higher than males. This finding may be traced back to the normal practices of teachers in the classroom where boys were given relatively more attention. As noted by Spender (1982), staff and students brought the assumption of male precedence with them into the classroom, and this resulted in boys demanding and teachers conceding to them a disproportionate amount of attention. Furthermore, boys were given more detailed instructions than girls. Teachers tend to do the work for girls. Thus, boys learned to be competent while girls learned helplessness.

This finding may also be attributed to the phenomenon in which teachers praise and criticise boys far more than girls (Brown, 1990; Dweck, Davidson, Nelson, & Enna, 1978). When boys were told off, it was usually for their misbehaviour; when they were praised, it was usually for good work. Based on this point, Dweck et al. (1978) assert that boys learned that they could perform well academically, and if they did not do well, it was probably because they were misbehaving or not trying. Girls, by contrast, were not told off much, but when they did, it was usually for poor work. So, girls learned that their work was not always adequate, and since this could not be attributed to lack of effort or attention, it must be due to some failing themselves. They lost confidence in their academic ability. This accounted for girls' higher level of anxiety when they were being asked a question in class, or being watched by a teacher while they carry out an experiment and report the results to the class.

In relation to science classroom anxiety, the results indicate that male and female students did not differ in their anxiety in the science classroom. This finding may perhaps be explained by the four-year exposure to learning secondary science whereby students may have acquired some skills of listening to science lectures and taking notes, reading a science textbook and sorting out what is most important in science content. Equally, this finding may also be explained by the culture in the Malaysian science classrooms which does not allow much experience of science anxiety among secondary students given that the chalk-and-talk and note-copying syndromes are ubiquitous and dominant particularly in mainstream schools (Ong, 2004) and that the laboratory work has not attained a favourable level (The Inspectorate of Schools [JNS], 2004).

Implications for Educational Practice

Based on the findings from this study, several implications for educational practice are proffered for consideration. Teachers should be aware of the subtle discrimination in terms of giving attention, assistance, and praise that is taking place in the classroom. Teachers should take account of their own classroom behaviour to ensure that they do not exhibit gender-biased behaviour towards their students. For instance, in the science class, boys and girls should be asked questions of similar level of difficulty. Teachers should praise boys and girls equally. Teachers should also refrain from accepting some behaviour from boys that they would not accept from girls. It is also important for the teachers to be able to recognise gender communication differences and allow for female communication patterns. This is essential to encourage active participation from girls.

When boys and girls are grouped together for performing science activities, they must share equally in the tasks at hand. The old pattern of boys-work-with-equipment-girls-write-down-numbers must be broken (Mallow, 1981). When female students encounter problems, teachers should refrain from completing an activity for the female students, but instead give specific instructions to help them complete their tasks.

Girls tend to be more afraid of making mistakes than boys are. They need to be shown that mistakes are part of the learning process. Besides, girls need to be encouraged to take reasonable risks (Guenther, 1992). There is also a need to defend science against superficial slights about the "dangers" of science, especially among the female students who are by nature more fearful and careful than their male counterparts.

Since science test was a factor of science anxiety, teachers should spend time teaching students how to prepare for science tests. Starting with easier questions and gradually progressing to the more difficult will provide a sense of success and motivation to the students. Tests should not focus on calculations and memorisation, but also on comprehension at a level appropriate to the students' cognitive development.

Many students find the problem-solving part of science difficult. Teachers should not assume that if a student can solve mathematical problems, he or she could automatically transfer those same skills to science subjects. Teachers should provide assistance and examples to show how the students' knowledge in mathematics can be applied in science problem solving. In cases when there is more than one way to solve a problem, the science instructor should use the approach that matches the students' cognitive level. It is also useful to explore one or two of the blind alleys that students might have taken in the course of trying to work the problems. This helps to demystify the process of doing science, thereby lowering anxieties as well as sharpening problem-solving skills.

Specifically aimed at alleviating problem-solving anxiety among girls in the science class, female teachers can portray themselves as female role models for their students. They should model for the girls examples of problem-solving ability, stressing the fact that although the problem is difficult, with a little work, it is possible to solve it. Female students should also be taught to give themselves credit, and not to attribute their accomplishments to luck (Brown, 1990). Besides, girls and boys should be given tasks that they should be able to equally accomplish with success. The recommendation given by SEAMEO RECSAM (2005) for curriculum planners to design a more gender-free curricula in science and mathematics supports the notion of equal opportunity for boys and girls in classroom interactions.

Many students, especially girls, find it very distressing when dissecting and handling parts of preserved specimens. In order to reduce squeamish anxiety among girls in particular, female teachers should model an interest in science and exploration — a willingness to explore and to tinker. If these teachers are timid about dissecting rats, observing snakes, insects, or other preserved specimens, the female students are likely to emulate that behaviour (Guenther, 1992). However, it would be injudicious to force the students if they are overly anxious to perform such activities. Forcing students to participate in objectionable activities may create more anxiety and avoidance. Another way to overcome this problem is to use alternative strategies that may include using models, working with interactive computers, or even being an active observer.

Girls and boys differ in their science learning styles and preferences (Omerod & Duckworth, 1975; Staberg, 1994). Girls prefer knowledge connected with their own and other people's lives, while boys are interested in apparatus and in making things. Girls prefer working together and they rely on books, on reading and writing. Boys play with the apparatus and with each other. Girls' learning style could be characterized by work and boys' by play, which is particularly obvious in laboratory work. Girls' theoretical way of approaching the subjects, partly owing to their unfamiliarity with tinkering and partly to their learned diligence, is one of the reasons for their craving to understand; another is their longing for overall comprehension. Special programmes to help these students to acquire the understanding of scientific concepts need to be carefully planned and implemented. Teaching strategies that cater to the different learning styles of both male and female students should be employed.

Secondary schools should consider using the SAI to detect students who have high levels of science anxiety, but indicate potential ability to perform well. Special programmes to determine the cause of the students' anxiety and to help these students overcome their anxiety need to be carefully planned and implemented. With an effective programme, it will be possible to reduce the students' anxiety about science and to enable them to enjoy the subject, to compete successfully in scientific endeavours and to feel competent in the subject.

Implications for Further Research

The sample of this study was limited to Form Four students of urban schools of Penang and therefore, the conclusions drawn are not generalisable to all urban schools in Malaysia. It is suggested that similar studies be replicated in other urban schools in different states throughout the country.

The variables examined in this study are not the only variables that may be related to science anxiety. Other demographic factors purportedly linked with science anxiety, such as type of schools (e.g., rural versus urban, coeducational versus single sex) grade level, and ethnicity are worth investigating in order to further illuminate the influence of these factors on the science anxiety of male and female students. Additionally, behavioural components such as students' attitudes towards science and their science teachers are also recommended for inclusion in further research.

Teaching strategies need to be developed and tested experimentally to determine if they are effective in lowering students' science anxiety. Local research involving experimental studies on the effects of various science teaching strategies on the science anxiety of male and female students should be conducted. This would provide evidence as to which teaching strategies would be more effective to overcome science anxiety for each gender.

Findings from the studies of Chiarelotte and Czernak (1987) and Rohana (1995) indicate that science anxiety is related to grade level. It would be beneficial to the body of literature on science anxiety if longitudinal research studies were to be conducted to gauge the gender differences in science anxiety as students advance from elementary through high school grades.

Conclusion

In summary, the self-rating on the Wynstra's (1991) six-factor Science Anxiety Inventory (SAI) indicate that Form Four females generally rated their overall science anxiety appreciably higher than did Form Four males. While there was no statistical significant difference between the ratings of males and females on science classroom anxiety, females rated appreciably higher than did males across five other subscales, namely danger anxiety, science test anxiety, math and problem-solving anxiety, squeamish anxiety, and performance anxiety. Accordingly, in can be concluded that gender difference in science anxiety does perpetuate into the 21st Century. However, such differences could be partly addressed within the classroom if teachers display equal treatment in their interaction with students and that the society recognises the equal standing as well as contribution from males and females in every facet of development and advancement.

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