CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

This study was specifically designed to investigate science anxiety of Form Two students with respect to the six dimensions of science anxiety, namely 'Danger Anxiety', 'Science Test Anxiety', 'Math and Problem-solving Anxiety', 'Squeamish Anxiety', 'Performance Anxiety' and 'Science Classroom Anxiety'. It sought to find out the top ten science-related activities that contributed to the students' science anxiety. In addition, it also determined whether science anxiety and its dimensions were significantly related to science achievement, attitude towards science and gender. The survey approach employed in this study involved the administration of three instruments, namely the SAI-A, SAT and ATSSA to the subjects of the study. This chapter would include the descriptions of the subjects of the study, instrumentation, pilot study and procedures for data collection.

3.1 The Subjects of the Study

This study involved a total of 148 Form Two students from Sekolah Menengah Zaaba, a co-educational secondary school about two kilometres from Kuala Pilah Town in the state of Negeri Sembilan Darul Khusus. The school was a semi-residential school where all the students were Malays and a majority of them

came from the rural area in the district of Kuala Pilah. This school was chosen on the basis that it would be a different setting from the urban schools selected by both Foo (1996) and Rohana Jantan (1996) in their studies. Moreover, as a part-time graduate student with work commitments, the researcher found that it was convenient to carry out her study in this school since it was only three kilometres away from her residence.

There were altogether five Form Two classes in the school. All the 70 male and 78 female students from the whole of Form Two classes participated in the study (see Table 3.1). The students were about 14 years old. They did not learn science as a separate subject in their primary schooling. These students were streamed according to the subjects they were taking. The students in 2A and 2B classes took the eight compulsory subjects whereas the students in 2U1, 2U2 and 2U3 classes took one extra subject – the Arabic language. It should be noted that the labels of 2A, 2B, 2U1, 2U2 and 2U3 classes did not imply any hierarchical order in terms of students' ability.

3.2 Instrumentation

Measures of the variables in this study were obtained using three instruments. The first instrument was the Adapted Science Anxiety Inventory (SAI-A) which measured the students' science anxiety. It was adapted from the Science Anxiety Inventory (SAI) developed by Wynstra (1991). The second instrument was the Attitude towards Science in School Assessment (ATSSA)

developed by Germann (1988). It was used to measure the students' attitude towards science as a subject in school. The third instrument was the Science Achievement Test (SAT) constructed by the researcher to assess the students' science achievement.

Table 3.1

Distribution of Subjects by Class and Gender

Class	Number of Students		
	Males	**Females**	**Total**
2A	13	21	34
2B	17	18	35
2U1	15	11	26
2U2	14	13	27
2U3	11	15	26
Total	70	78	148

3.2.1 The Adapted Science Anxiety Inventory (SAI-A)

The SAI is a self-report Likert-type instrument developed by Wynstra (1991) to measure science anxiety among high school students in the United States of America. Each item in the SAI constitutes a statement concerning a science-related activity which may arouse science anxiety among students. A Malaysian researcher Rohana Jantan (1995) adapted the SAI for use in her study to measure science anxiety among Form One, Form Two and Form Three students in four schools in Kuala Lumpur. Later, this version of SAI was adopted by Foo (1996) in a study conducted on Form Four students from a few schools in Penang. However, the researcher of the present study found that this adapted version was not suitable for the Form Two students because some of the items were meant for students at higher level. In order to achieve the aims of this study, the original SAI was adapted once again to measure science anxiety among the Form Two students. Some items of Rohana Jantan's (1995) version of SAI were also retained in the SAI-A.

Before adapting the SAI, the researcher reviewed the principal component analysis carried out by Wynstra (1991) on the original 49 items, in which a loading of .50 was used as the minimum to be included in a factor. Wynstra found that 9 items loaded on 'Danger Anxiety', 8 items loaded on 'Science Test Anxiety', 7 items loaded on 'Math and Problem-solving Anxiety', 6 items loaded on 'Squeamish Anxiety', 5 items loaded on 'Performance Anxiety' and 3 items loaded on 'Science Classroom Anxiety'. A total of 11 items did not load on any factor.

As a whole, there were only 38 items in the SAI which loaded on either one of the six factors of science anxiety. Thus, in the present study, the SAI would be adapted based on these 38 items to ensure the suitability of items for Form Two level in Malaysian contexts. In Rohana Jantan's (1995) study, the adaptation also began with the same items. These items are shown in Appendix A.

A total of 7 items as shown in Table 3.2 were deleted from the SAI. The items were deleted after considering the Form Two Science syllabus which did not cover the science-related activities as mentioned in these items. Only students in the upper forms had experienced these activities in science classes.

Modifications were made on 16 SAI items by changing a few words in the items or rephrasing the whole items. Table 3.3 shows the modified items and their respective dimensions. In Items 1, 5, 6, 13, 14 and 15, the words such as 'your' were changed to 'my', and 'you' to 'me' or 'I'. These changes were made so that the respondents could feel the situations described by the items. The words such as 'lecture' were also changed to 'teaching' or 'present the lessons' to suit the contexts of Malaysian secondary schools. 'Science chapter test' in Item 2 was replaced by 'science test' which covered either a science chapter or any part of a chapter. It should be noted that there were only five chapters in the Form Two Science syllabus. Items 7, 8, 9 and 12 were modified because the science-related activities mentioned in the items were irrelevant to the Form Two students. Furthermore, modifications were also made on Items 3, 4, 10 and 11 to make them suitable for the Form Two level. Item 16 was rephrased as 'Studying a fresh

specimen of a cow's eye in the science class' because the original item 'Looking at real cow eyes in science class' was not literally correct.

A total of 8 new items as shown in Table 3.4 were added to the SAI-A. The first item in the list was extracted from Rohana Jantan's (1995) version of SAI and the other 7 items were constructed by the present researcher. The new items include one item from 'Danger Anxiety', two items from each dimension of 'Math and Problem-solving Anxiety' and 'Performance Anxiety', and three items from 'Squeamish Anxiety'.

Table 3.2

Deleted SAI Items

Item	Dimension
Dissecting a frog for a science class.	Squeamish Anxiety
Following an example of a math problem in a science book that uses term like "log" or "cosine".	Math and Problem-solving Anxiety
Working out heredity problems in genetics.	Math and Problem-solving Anxiety
Pricking your finger to do blood typing.	Squeamish Anxiety
Lighting a pilot light on your stove or furnace.	Danger Anxiety
Taking a lab practical exam.	Science Test Anxiety
Having your science teacher demonstrate something that explodes and makes a loud noise.	Danger Anxiety

Table 3.3

Modifications on the SAI Items

	SAI	SAI-A	Dimension
1.	Taking notes while your science teacher lectures.	Taking notes while my science teacher presents the lessons.	Science Classroom Anxiety
2.	Taking a science chapter test	Taking a science test.	Science Test Anxiety
3.	Interpreting a graph in your science book.	Answering questions regarding a graph.	Math and Problem-solving Anxiety
4.	Answering questions for a science homework assignment.	Answering questions for science homework.	Science Classroom Anxiety
5.	Having a science teacher ask you a question in class.	Having my science teacher ask me a question in class.	Performance Anxiety
6.	Asking your science teacher a question about something you do not understand.	Asking my science teacher about something I do not understand.	Performance Anxiety
7.	Collecting saliva to examine with a microscope.	Collecting saliva to examine the effect of its enzyme on food.	Squeamish Anxiety
8.	Working with high voltage batteries.	Working with an electrical power supply.	Danger Anxiety

(table continues)

Table 3.3 (continued)

	SAI	SAI-A	Dimension
9.	Putting the numbers into a formula to solve a problem on motion.	Putting the numbers into a formula to solve a problem involving 'work' and 'power'.	Math and Problem-solving Anxiety
10.	Doing a science fair project.	Doing a science project.	Performance Anxiety
11.	Working out story problems on density.	Working out word problems on density.	Math and Problem-solving Anxiety
12.	Collecting insects for a science project.	Collecting cockroaches to use in an experiment.	Squeamish Anxiety
13.	Sitting for a full class period and listening to your teacher lecture on a science topic.	Sitting for a full class period and listening to my teacher teaching a science topic.	Science Classroom Anxiety
14.	Having your teacher watch you do a laboratory procedure.	Having my science teacher watch me do a laboratory procedure.	Performance Anxiety
15.	Having your science teacher explain a lab procedure that may be dangerous.	Having my science teacher explain a laboratory procedure that may be dangerous.	Danger anxiety
16.	Looking at real cow eyes in science class.	Studying a fresh specimen of a cow's eye in the science class.	Squeamish Anxiety

Note : The item numbers are only applicable for this table

Table 3.4

New Items of the SAI-A

Item	Dimension
Collecting cheek cells to be observed with a microscope.	Squeamish Anxiety
Identifying an organism using the identification key in a science book.	Math and Problem-solving Anxiety
Using chicken blood to observe the colour of oxygenated and deoxygenated blood.	Squeamish Anxiety
Heating something with a bunsen burner.	Danger Anxiety
Changing quantitative units, for example, from square centimetres (cm^2) to square metres (m^2).	Math and Problem-solving Anxiety
Observing real teeth of animals.	Squeamish Anxiety
Explaining the results obtained from an experiment.	Performance Anxiety
Answering questions based on the experiment which has just been carried out.	Performance Anxiety

The complete version of SAI-A consisted of 39 items as shown in Appendix B, in which 15 items were from the original SAI items, 16 items were the modified items, 7 items were the newly constructed items and one item was extracted from Rohana Jantan's (1995) version of the SAI. The SAI-A comprises the six dimensions of science anxiety as in the original SAI. The SAI-A dimensions and

their corresponding items are shown in Table 3.5 while the distribution of the SAI-A items is presented in Appendix C.

Table 3.5

SAI-A Dimensions and Their Corresponding Items

Dimension	Item Number	Total Number
Danger Anxiety	1, 8, 11, 15, 17*, 18**, 20, 24*	8
Science Test Anxiety	4*, 10, 23, 25, 27, 29, 33	7
Math and Problem-solving Anxiety	2, 6*, 12**, 19*, 26*, 30, 36**	7
Squeamish Anxiety	5***, 13**, 16*, 28*, 31, 35*, 37**	7
Performance Anxiety	9*, 14*, 21*, 22, 34*, 38**, 39**	7
Science Classroom Anxiety	3*, 7*, 32*	3
Total Number of Items		39

* denotes item adapted from the SAI

** denotes new item constructed by the researcher

*** denotes item extracted from Rohana Jantan's version of the SAI

The respondents in Wynstra's (1991) SAI rated their responses on a five-point Likert scale by circling the number that best indicated how nervous they would feel as shown in Table 3.6.

In Rohana Jantan's (1995) and Foo's (1996) studies, the respondents were also given the same instruction as mentioned above. However, the format was modified by labelling all the numbers as shown in Table 3.7.

Table 3.6

Rating Scale of Wynstra's SAI

Degree of Nervousness	Not At All Nervous		Moderately Nervous		Very Nervous
Score	1	2	3	4	5

Table 3.7

Rating Scale Used by Rohana Jantan and Foo

Degree of Nervousness	Not At All Nervous	Slightly Nervous	Moderately Nervous	Nervous	Very Nervous
Score	1	2	3	4	5

In this study, the researcher used a rating format which required the respondents to tick in the column bearing the labels "Not At All Nervous",

"Slightly Nervous", "Moderately Nervous", "Nervous" and "Very Nervous". The researcher assumed that this would be much easier for the respondents to indicate their levels of nervousness. Furthermore, because the numbers were not shown in the SAI-A, it can avoid the risk of causing confusion among the respondents.

A rating scale which was the same as that used by Rohana Jantan (1995) and Foo (1996) was used for the SAI-A as in Table 3.7.

Using the above rating scale, higher scores in the SAI-A would indicate higher level of science anxiety. The minimum and maximum possible scores for each SAI-A dimension are shown in Table 3.8.

Table 3.8

Minimum and Maximum Scores of SAI-A Dimensions

SAI-A Dimension	Number of Items	Minimum Score	Maximum Score
Danger Anxiety	8	8	40
Science Test Anxiety	7	7	35
Math and Problem-solving Anxiety	7	7	35
Squeamish Anxiety	7	7	35
Performance Anxiety	7	7	35
Science Classroom Anxiety	3	3	15
Total	39	39	165

3.2.2 The Attitude towards Science in School Assessment (ATSSA)

In this study, the ATSSA was used to determine the extent to which the Form Two students liked or enjoyed science as a subject in school.

The ATSSA is a 14-item Likert-type instrument developed by Germann (1988) to measure a single dimension of a general attitude towards science, that is, how the students felt towards science as a subject in school. The construct of attitude towards science does not include other dimensions of attitudes towards science such as scientific attitude, attitude towards scientist, attitude towards methods of teaching, attitude towards scientific interest and so on.

There are 10 positive and 4 negative statements randomly listed in the ATSSA. In the present study, the item "Science is a topic which I enjoy studying" was modified to "Science is a subject which I enjoy studying". Table 3.9 shows the distribution of the ATSSA items. These items are presented in Appendix D. The rating scale for the positive statements is as follows :

1 for Strongly disagree

2 for Disagree

3 for Neither Agree Nor Disagree

4 for Agree

5 for Strongly Agree

The negative statements were scored in a reverse manner. The possible scores for the ATSSA ranged from 14 to 70.

Table 3.9

Distribution of the ATSSA Items

Type of Statement	Item Number	Total Number
Positive statement	1, 3, 4, 5, 6, 8, 9, 11, 12, 13	10
Negative statement	2, 7, 10, 14	4
Total		14

In four studies carried out by Germann (1988) on a total of 492 students at grade seven through grade twelve, the Cronbach alpha reliability coefficients were estimated to be .96, .97, .96 and .95 respectively. In addition, a *t*-test computed for the ATSSA scores of two groups revealed that this instrument was able to distinguish significantly between the group which fostered a negative attitude and the other group which fostered a more positive attitude.

In a Malaysian study involving 225 Form Two students from a secondary school in the state of Selangor, Lau (1997) used the ATSSA to examine the relationship between the students' perception of science laboratory environment and the attitude towards science. The Cronbach alpha reliability coefficient of the ATSSA was found to be .87, indicating that it had satisfactory internal consistency.

3.2.3 Contextualization of the SAI-A and ATSSA

A complete set of the SAI-A and ATSSA were sent to a panel of evaluators to check whether the items had been well adapted and contextualized for use among Malaysian Form Two students. They were also provided with Table 3.2, Table 3.3 and Table 3.4 to check whether :

i. the deletion of the original SAI items could be accepted,

ii. the new items were suitably classified into their respective dimensions, and

iii. any other new items should be further included.

The panel consisted of two science teachers from two different secondary schools and a lecturer of the Math and Science Department in a teacher training college. The members of the panel were selected on the basis that they were science graduates and had at least 5 years of teaching experience in secondary school science. Both the science teachers were teaching Form Two science and one of them possessed a degree in Master of Science Education. The members were also proficient in the English language.

All the members found that the items in both SAI-A and ATSSA were well contextualized and suitable for use among Form Two students. They agreed with the deletion and modifications made on the SAI items. They also agreed with the classification of the new items into the SAI-A dimensions. They suggested no further changes be made on the SAI-A and ATSSA.

3.2.4 Translation of the SAI-A and ATSSA

The English versions of SAI-A and ATSSA were translated into Bahasa Melayu by the researcher. The English and Bahasa Melayu versions of both instruments were then presented to two teachers who had extensive experience with teaching Bahasa Melayu at lower and upper secondary levels to check for language clarity, grammar, as well as the accuracy of the translation. Both of the teachers were also proficient in the English language. Based on their feedback, a few changes were made. The refined Bahasa Melayu version of SAI-A and ATSSA are shown in Appendices E and F respectively.

3.2.5 The Science Achievement Test (SAT)

The Science Achievement Test (SAT) was constructed by the researcher in Bahasa Melayu (see Appendix G). It was used to assess the students' science achievement in terms of the acquisition of knowledge, understanding and applications of concepts and theories over the content area of the last three chapters of the Form Two Science syllabus. It was expected that the students would have completed these chapters before the administration of the test.

The SAT was constructed based on various sources accessible to the researcher. The sources of the SAT items are shown in Appendix H. In constructing the SAT, the researcher classified the items into two cognitive levels according to the Bloom's taxonomy. Level I refers to knowledge and

understanding while Level II refers to application. Table 3.10 presents the distribution of the SAT items according to the cognitive levels.

For each SAT item, four choices of answers of A, B, C and D were provided. Students were required to mark their best choice on a separate answer sheet. Each correct answer was awarded a score of one point whereas an incorrect answer was given a score of zero.

3.2.6 Content Validation of the SAT

To establish the content validity of the SAT, it was submitted to three experienced science teachers who had been teaching Form Two science for at least ten years. Their task was to check the structure of the items and to determine whether the major contents of the chapters were tested by these items. In addition, they were also requested to check whether the items were well classified into the cognitive levels as shown in Table 3.10. All the members in the panel found that the SAT had content validity but required a few changes on the structure of certain items. They also agreed with the classification of items in relation to the two cognitive levels. Based on the comments and suggestions, changes were made accordingly to refine the items.

Table 3.10

Distribution of the SAT Items

Content	Item Number		Total
	Cognitive Level I	Cognitive Level II	
Chapter 3 Food and Release of Energy			
3.1 Classes of food	38	31	2
3.2 Balance Diet		18, 20, 43	3
3.3 Dentition	25	28	2
3.4 Digestive System	3, 7, 8, 49	10	5
3.5 Transport System in Man and Plants	12, 13, 33	41	4
3.6 Respiratory System	17,21,50,42		4
3.7 Excretion of Man and Plants	16, 40		2
Chapter 4 Interdependence between Living Things and the Environment			
4.1 Habitat, Community and Ecosystem	6,11,14, 29		4
4.2 Relationship between Food and Energy Distribution	2, 5	4	3
4.3 Interaction between Living Things	1, 35	9, 34, 47	5
4.4 Accommodation of Living Things in relation to Changes of Climates in the Environment	19, 36, 39	32	4
4.5 Preservation of Living Things		46	1
Chapter 5 Force and Movement			
5.1 Force and Its Measurement	15, 30	23, 36,45, 26	6
5.2 Movement and Friction	22, 37		2
5.3 Energy, Work and Power	48	24, 27	3
Total	31	19	50

3.3 Pilot Study

A pilot test using the Bahasa Melayu versions of the SAI-A, ATSSA and SAT were conducted on 36 students randomly selected from the Form Two classes in a school in Kuala Pilah. The purpose of the pilot study was to detect if there were still any ambiguities regarding the language and structure of items in the instruments before carrying out the actual study. It would also provide an estimate of time needed to complete each instrument.

The time allotted for the pilot-testing sessions was 30 minutes for the SAI-A, 20 minutes for the ATSSA and 60 minutes for the SAT. Both the SAI-A and the ATSSA pilot-testing were carried out before the school recess with a 5-minute interval while the SAT pilot-testing was carried out after the break. During the pilot-testing, the students were encouraged to ask if they could not understand the words and phrases in the items. However, it was found that these students did not encounter any difficulties in understanding the items and they only took about 20 and 10 minutes to complete the SAI-A and ATSSA respectively. Based on the results of the pilot study, the researcher adjusted the time allotted for the SAI-A from 30 minutes to 20 minutes in the actual study. The length of time allotted for the ATSSA was also changed from 20 minutes to 10 minutes. However, no further modifications were made on the items of the three instruments since all of the students could understand the items.

3.4 Collection of Data

Once the research proposal of this study was approved by the Vetting Committee of the Faculty of Education, Universiti Malaya, a letter was sent to the Educational Planning and Research Division (EPRD) of the Ministry of Education seeking permission to carry out the study. The permission was granted in August, 1997. Subsequently, another letter was sent to the State Education Department of Negeri Sembilan to seek further permission to collect data in two secondary schools within the state.

After obtaining the permission from the department, the researcher visited the schools on the next day to make arrangement with the principals and teachers for data collection.

The pilot study was carried out a week before the actual study which was scheduled on October 8, 1997. In the pilot study, the researcher personally administered the SAI-A and ATSSA to the students. As for the actual study, since each of the instrument was administered to the students at the same time, the researcher was assisted by the school science teachers. A briefing was given to the teachers prior to the data collection to ensure that every teacher in charge would give the same instructions to the students and follow the same procedures needed to carry out the data collection. Table 3.11 shows the data collection schedule for this study.

The SAI-A and ATSSA were administered to the students in two separate sessions on the same day. Time allotted for each session was 20 minutes for the

SAI-A and 10 minutes for the ATSSA. There was an interval of 5 minutes between the two sessions. Before the students began to answer, they were informed of the purpose of the survey and were assured of the confidentiality of their responses. This was to help them to respond honestly and freely without any worries and doubts. In addition, specific instructions on how to answer the questionnaires were also explained clearly to the students.

The administration of the SAT took place one week later. Time allotted for the SAT was 60 minutes. With the collaboration of the science teachers who were teaching in the school, it was administered to the students as a form of trial final examination. Prior to this trial final examination, the students had been informed three weeks earlier by their teachers so that they would have ample time to study. The data were collected by the teachers and delivered to the researcher within two days. Data collection of the whole study was completed within a duration of two weeks.

Table 3.11

Data Collection Schedule

Session	Instrument	Number of Items	Time Allotted (Minutes)
1	SAI-A	39	20
2	ATSSA	14	10
3	SAT	50	60