A STUDY OF SINGAPORE FEMALE PRIMARY TEACHERS' SELF-EFFICACY FOR TEACHING SCIENCE

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Appendices

Declaration

The thesis results from my own work and had not been offered previously in candidature for any other degree in this University or other University.

STATEMENT OF COPYRIGHT

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ABSTRACT

According to Bandura, self-efficacy is defined as an individual's judgment of their capability to organize and execute the courses of action required to attain designated types of performances. It has been proposed that there is a strong relationship between Science teaching efficacy beliefs and Science teaching behaviors (Sarikaya, 2005).

Research has shown that the self-efficacy of teachers affects the performance of their students. Female teachers in Singapore primary schools made up more than 80% of the teaching population and with many reports that teachers are shunning Science and that women possess low Science self-efficacy, one would expect that could be the case for Singapore female teachers as well. Despite this, the 'Trends in International Mathematics and Science Study' (TIMMS) 2007 reported that the scores of Singapore primary four students were amongst the top internationally and this was not the first time they had achieved such accolade. There was also no significant difference between the boys' and girls' results in the TIMMS.

The aim of this study is to determine the self-efficacy of Singapore female primary Science teachers relative to their male counterparts (N=80), and identify enablers and barriers faced by high and low efficacy female Science teachers. A mixed methods approach was used in this research. Analysis of the Science Teaching Efficacy Belief Instrument (STEBI - A) revealed that although male teachers reported significantly higher PSTE scores relative to female teachers, an independent samples t-test showed that the difference was not significant. For the STOE, again Male teachers scored higher than females but given the very small difference between the means, the difference was not significant. It is believed that the trend is probably reflective of a phenomenon that male teachers have higher PSTE than their female counterpart but naturally the data does not support this claim.

From the STEBI-A scores, four female teachers were selected for a semi-structured interview to explore in depth accounts of Singapore female primary teachers' attitude towards teaching Science. Recommendations are made to raise self-efficacy of the female teachers and to optimise primary Science teaching in Singapore.

Keywords: Self-efficacy, Science Education, Teacher Education, Gender

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OVERVIEW OF THE CHAPTERS

This study's primary aim was to measure the self-efficacy of Singapore female primary Science teachers and identify enablers and barriers that female Science teachers faced in their teaching. It is divided into six chapters with each mirroring its purpose and the way this thesis is structured.

CHAPTER 1

In Chapter One, the purpose and background of this thesis is introduced. This is followed by the importance of Science education in Singapore. Next is the researcher's motivation that led to this research, which was primarily derived from his ten-year experience as a primary teacher and tutor. Then, brief descriptions of the current Singapore education system and the latest primary school Science syllabus in Singapore are given.

Following that, the reasoning that the pupils' excellent results in the 2007 TIMMS could be due to their Science teachers is put forward. This leads to the question of how low or how high the self-efficacy of the female Science teachers who made up more than 80% of the teaching population in Singapore was.

CHAPTER 2

In Chapter Two, the review of relevant literature in order to learn about the definitions of self-efficacy given by different scholars (Bandura, Schunk, Pajares, etc.) and identify studies that had been conducted relating to the topics of self-efficacy, Science education and women in Science is undertaken.

There was no shortage of literature related to the abovementioned subject which is sub-categorised into self-efficacy, teacher efficacy, Science teacher self-efficacy and women Science self-efficacy. The characteristics and implications of high and low efficacy teachers were discussed. Following that, the confusion amongst the constructs of self-efficacy, self-concept, self-esteem, self-confidence and perceived control was addressed. The possible interventions to increase self-efficacy as Bandura (1986) suggested and the importance of mentorship and professional development for both the mentor and mentee are provided.

In order to measure the Science self-efficacy of the female teachers against their male counterparts, different methods that researchers have employed to measure teacher self-efficacy are reviewed.

CHAPTER 3

The research methodology (mixed methods design: STEBI-A, Survey & Semi-structured Interview) for this study is presented in Chapter Three. Firstly, the researcher's awareness and understanding of the different philosophical, epistemological and ontological positions held by qualitative and quantitative approaches to research and the contradictions which may arise by combining these approaches are presented. Next is the report on the strengths and weaknesses of different research traditions, approaches and strategies and the different ways in which methods can be mixed.

The results from the STEBI - A allowed the identification of teachers with high and low Science efficacy. Four teachers were selected for the interviews. A pilot study involving three teachers was conducted to clarify any possible unforeseen problems before mailing the surveys out to teachers of different schools. The contribution of the pilot study was stated, after which a review of ethical issues in qualitative interviewing was carried out.

Next is the report on the data collection process of the survey such as recommendation to raise the response rate, timeline of the study and the obstacles faced during data collection. Following that, how the teachers were chosen for the four interviews and how the interviews are conducted are discussed. The transcription system, the significance and outcome of the study, and finally the research hypothesis are provided.

CHAPTER 4

Chapter Four is divided into two sections. In section one, the demographic of the teacher participants is presented. The findings after the data analysis of the Science Teaching Beliefs Instrument (STEBI-A), and the 80 teachers' responses to my questions about their Science teaching experiences are reported. Analysis of the Science Teaching Efficacy Belief Instrument (STEBI - A) revealed that although male teachers reported significantly higher PSTE scores relative to female teachers, an independent samples t-test showed that the difference was not significant. For the STOE, again Male teachers scored higher than females but given the very small difference between the means, the difference was not significant. The evidence suggests that there was no difference in mean scores of PSTE or STOE between males and females. It is believed that the trend is probably reflective of a phenomenon but naturally the data does not support this claim.

Mathematics was found, amongst the three core subjects of English, Mathematics and Science, that the male and female teachers had the most confident to teach. English was placed last. Science was the subject that they consulted their colleagues about most frequently. Majority of the female teachers would consult their colleagues when they encountered problems in their Science teaching. Almost all the female teachers disagreed that male teachers could teach Science better than them. As for the question of whom they had modelled themselves on as a Science teacher, one third of the female teachers indicated an HOD or a colleague or colleagues. Half of the female teachers reported that an ex-teacher / lecturer had inspired them to be better Science teachers. Their students also gave them the affirmation that they could teach Science well. To raise the teachers' Science self-efficacy, schools organised workshops, courses, sharing sessions, etc.

The teachers also disclosed the barriers they faced while teaching science. These included limited time, limited resources, absence of a laboratory assistant, their lack of content/pedagogical knowledge and lack of feedback from their supervisors / mentors.

In section 2, four interviews with the teachers who had scored the lowest and highest in their PSTE are presented. The interview mainly focused on their Science background, their experiences in schools (enablers and barriers that affected their Science teaching) and those people (school teachers, colleagues, etc.) who influenced them in their current Science teaching. The teachers also gave their suggestions to raise the Science efficacy of teachers.

CHAPTER 5

In Chapter five, the four interviews and the teachers' responses to the survey are discussed. Enablers (e.g. passion for the subject; outgoing personality, inspiring role model(s) in school, strong content/pedagogical knowledge, supportive supervisor, etc.) and also the barriers (e.g. time restrictions, lack of Science content knowledge, lack of an assistant and resources, unsupportive/unqualified supervisor and limited feedback from supervisors / mentors) faced by Science teachers are identified.

Recommendations are made to raise their self-efficacy which included a time extension for Science lessons and outdoor activities. The feasibility of starting Science education in primary 2 instead of primary 3; having more allied educators to assist the teachers; conducting more professional development programmes to improve content knowledge of the teachers and finally to develop the mentorship programme, are suggested.

CHAPTER 6

The conclusion of the thesis is presented in the final chapter. the unique contribution and limitation of this study are reported. Also, the implications of the study for teachers and schools, policy makers at NIE and MOE and recommendation for future research are discussed. And finally, the closing remarks of the thesis.

GLOSSARY OF TERMS & ACRONYMS

STEBI-A …………………. SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT A (IN-SERVICE TEACHER)

STEBI-B ……………….. SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT B (PRE-SERVICE TEACHER)

PSTE ……………………. PERSONAL SCIENCE TEACHING EFFICACY

STOE …………………..... SCIENCE TEACHING OUTCOME EXPECTANCY

A*STAR ………………… AGENCY FOR SCIENCE, TECHNOLOGY & RESEARCH

TIMMS …………………… TRENDS IN INTERANTIONAL MATHEMATICS & SCIENCE STUDY

MOE ……………………… MINISTRY OF EDUCATION

NIE ……………………….. NATIONAL INSTITUTE OF EDUCATION

PTE ………………………. PERSONAL TEACHING EFFICACY

GTE ………………………. GENERAL TEACHING EFFICACY

HOD ……………………… HEAD OF DEPARTMENT

CCA ………………………. CO-CURRICULA ACTIVITY

ITE ……………………….. INSTITUTE OF TECHNICAL EDUCATION

CHAPTER 1

INTRODUCTION

CHAPTER 2

LITERATURE REVIEW

CHAPTER 3

RESEARCH METHODOLOGY

CHAPTER 4

DATA ANALYSIS & RESEARCH FINDINGS

CHAPTER 5

DISCUSSION & SUMMARY OF RESEARCH FINDINGS

CHAPTER 6

CHAPTER 1

1.1 INTRODUCTION

This chapter begins with the importance of Science education in Singapore, particularly in recent years since her independence from Britain and the pressing need to train young local Scientists. In the next section I will define the terms 'Science', 'Engineering' and 'Technology' and give a brief introduction to the Singapore primary school syllabus, after which I will set out my primary motivation for embarking on this thesis and its significance. This is followed by the background of the research.

1.2 DEFINITIONS

In the Oxford Dictionary Press 2003, the term 'Science' is defined as 'the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment'. 'Engineering' is defined as: the branch of Science and Technology concerned with the design, building, and use of engines, machines, and structures', while 'technology' is defined as: the application of scientific knowledge for practical purposes, especially in industry.

Life Sciences, also called Bioscience, involves several branches of Science such as Biology, Medicine, Anthropology and Ecology that deal with living organisms and their organisation, life processes, and relationships to each other and their environment. Physics is defined as the Science of matter and energy and of interactions between the two, grouped in traditional fields such as Acoustics, Optics, Mechanics, Thermodynamics and Electromagnetism, as well as in modern extensions including Atomic and Nuclear Physics, Cryogenics, Solid-state Physics, Particle Physics and Plasma Physics.

Hence for the purpose of this study, the three terms, Science, Engineering and Technology are all categorised as Science.

1.3 MOTIVATION FOR RESEARCH

I began my career as a primary school teacher in 2001. English, my lingua franca since primary school to graduate school at New York University, proved to be effortless for me when I first taught the language to a class of 40 students at a local primary school in Singapore. Mathematics had only required me to do some brushing upon the new syllabus that involves a lot of 'model drawing' – a pictorial or 'boxes' method to work out the answer. Science presented me with the most challenges. Due to the ever-changing world of technology, Science education in Singapore primary schools has become more demanding than what I was taught two to three decades ago. Topics taught to me in secondary school are now found in primary school Science textbooks, and new topics have also been added.

Whilst the concepts in the current Science textbook were straightforward and easily understood, Science questions posed by my primary three students who were exposed to the omnipresent media were a challenge for even a college graduate like me. How could I, a new teacher, who holds a Master's Degree, be incapable of answering the pupils' questions? It was certainly difficult for me to take on "the role of educating children to become scientifically literate, socially adept and enthusiastic lifelong learners" (Watters & Ginns, 2000, p.301).

Whilst I was undertaking my Masters' Degree at New York University, I was to a certain extent influenced by the works of my professor and department chairperson, Professor Deborah Borisoff, whose scholarly interests include Gender and Communication. I became interested in gender issues and even wrote a master thesis titled '*Women in the Media.*' Three of my coursework assignments at Durham University prior to the writing of this thesis were not far removed from gender issues in education too.

In the '*Psychology of the Learner*' EdD module at Durham University, Dr. Barbara Riddick, the lecturer in introduced me to the constructs of self-efficacy, self-concept, self-esteem and self-confidence. I was especially interested in the studies of Albert Bandura, Frank Parajes, Dale Schunk and Barry Zimmerman. Further reading on the studies of self-efficacy in books and journals yielded numerous reports on gender difference in this subject matter. There is no lack of studies to show that elementary teachers have been avoiding teaching Science in the elementary school curriculum and that they prefer teaching other subjects in preference to Science (Stefanich & Kelsey, 1989). Their attitude and self-efficacy towards learning and teaching Science are also reported as negative in several studies.

The majority of primary teachers in Singapore teach many subjects, i.e. English, Mathematics, Science, Social Studies, Health Education, Physical Education, etc., and may not be equally effective in teaching all of them. It is primary Science, though, that most troubles the elementary teachers (Enochs & Riggs, 1990).

As an English Mathematics and Science school teacher and private tutor for ten years, I have worked with mostly female teachers who made up the majority of primary school teachers in Singapore. I had personally encountered female colleagues avoiding Science and seen how they had struggled with teaching Science.

However, I had also met some great female Science teachers like the Science HOD in my school. She was one teacher who inspired me tremendously with her confidence, her deep understanding of Science content knowledge and her clarity in explanation of this subject.

During some casual talks with students from other classes and many other schools, I learnt that their teachers were spending more time on English and Mathematics. As for Science, as long as the syllabus was covered, the worksheets were completed, and experiments (generally very few of them) at the Science laboratory were carried out, that was it for the teaching of Science in school. Field-trips to the Science Centre or Zoo were held only once or twice a year.

Although the abovementioned number of teachers was too small to offer a generalisation, the students' comments reminded me of the studies I read about teachers' attitudes towards Science - but those studies were generally conducted overseas by researchers in the United States, the United Kingdom, Australia, etc. Could this also happen in Singapore? This prompted me to begin thinking of questions, some of which were: 'What are the Singapore primary teachers' attitudes and self-efficacy towards the teaching of Science, particularly the female teachers?' 'What are the barriers they face when they are teaching Science?' 'What are the enablers that made them proficient Science teachers?' 'Which is their least and most confidence subject to teach?'

1.4 BACKGROUND OF RESEARCH

To better appreciate this research paper, I will first give a brief introduction of the primary education in Singapore, followed by a brief history of Singapore and its education system since the 1970s and the current primary school Science syllabus.

1.4.1 PRIMARY EDUCATION IN SINGAPORE

All the primary and secondary schools in Singapore, including the junior colleges and pre-universities, are under the wings of the Ministry of Education. The free and compulsory primary education in Singapore starts at age six. It comprises of two stages. The first is the foundation stage from Primary 1 to 4 in English, Mother Tongue (Chinese, Malay, Tamil, etc.) and Mathematics.

The pupils also take subjects like Civics and Moral Education, arts and crafts, music, health education, social studies, and physical education (graded but non-examined). Formal Science education only begins in Primary 3. The Primary 4 examinations developed by each individual school for its own pupils determine if a pupil can take their Mother Tongue at the higher, standard or foundation levels; Science and Mathematics can be taken at the standard or foundation levels, in Primary 5 and then subsequently in Primary School Leaving Examination (PSLE).

The second stage is the two-year orientation stage from Primary 5 to 6. Pupils take the PSLE, a final national examination at the end of Primary 6 education. Based upon the pupils' performance in this examination, they will then be channeled to the different secondary education tracks or streams; they are: 'Special', 'Express', 'Normal (Academic)', or 'Normal (Technical). From there they move on to the next level in junior college, pre-university, polytechnics or the Institute of Technical Education (ITE) or other private institutions.

1.4.2 PRIMARY SCHOOL SCIENCE SYLLABUS IN SINGAPORE

In the revised syllabus (MOE, 2010) towards the learning of Science in Singapore primary school science, the themes are based on what students can relate to in their everyday experiences and to the commonly observed phenomena in nature (MOE, 2010).

The five themes chosen are: Diversity, Cycles, Systems, Energy and Interactions. These themes encompass a core body of concepts in both the Life and Physical Sciences. As the Ministry of Education (MOE, 2010) puts it, "This syllabus is based on the Science Curriculum Framework and emphasises the need for a balance between the acquisition of science knowledge, process and attitudes. In addition, as and where the topics lend themselves, the technological applications, social implications and the value aspects of science are also considered. It also emphasises the broad coverage of fundamental concepts in the natural and physical world."

In their overview of the primary Science syllabus, the ministry has incorporated mostly the two major fields of science, namely Life Sciences and Physics in the new syllabus:

- Lower Block (Primary 3 and 4), the pupils will learn about Diversity (Living and non-living things, their general characteristics and classification; and materials); Cycles (Plants and animals; and matter and water), System (Plant system – their parts and functions; Human digestive system); Interactions of forces (Magnets); and Energy (forms and uses on light and heat).

- In the Upper Block (Primary 5 and 6), the pupils will learn more in-depth topics on Cycles (plants and animals reproduction; and the water cycle); Plant and Human System (Respiratory and circulatory systems; Cell and electrical); and Energy forms and uses (Photosynthesis) and Energy conversion.

1.4.3 SINGAPORE SCIENCE EDUCATION

In the 1970s the Singapore Government began restructuring her education policies, through expanding technology and computer education. Financial incentives were given to industrial enterprises to accelerate productivity.

From the mid-1980s onwards, Singapore's economic growth strategy began to move into a new phase of higher value-added products which were to include Precision Engineering, Computer Peripherals, Software manufacture, Information Technology, Biotechnology, Robotics and Financial Services. To support these developments, Science and Engineering education was expanded and developed. University Engineering enrollment increased threefold within a decade from 330 in 1976 to 1143 by 1985. This production of engineers in the 1970s and 80s was linked to the shift to technology-based higher value added industries. During this period, Singapore's production of engineers in proportion to its population was nearly double that of Britain (Tan, Gopinathan & Ho, 1997).

Since the rise of China and the rest of the countries in South-east Asia like Indonesia, Malaysia and Thailand that offer cheaper labour and plenty of raw materials, Singapore has begun to lose her lustre. The country is no longer favoured by companies that used to set up their production lines there churning out countless goods. Thousands of workers lost their jobs after those MNCs stopped their operations in Singapore and moved out of the country. The government knew that economic diversification was the way to go as it would reduce the country's economic volatility. Moreover, more revenue could be generated from a wide range of profitable sectors. One sector would be the knowledge-based industries.

The field of Life Sciences is widely seen as the next major technological revolution after the Internet where new knowledge and discoveries generated as a result of genome and molecular biology research will have a major impact on the life science and pharmaceutical industries, healthcare, food and nutrition, people and the environment (NTU, 2010). Again, Singapore, an island nation without any natural resources but manpower and brainpower, is poised for the revolution with the potential huge returns of life sciences. Science education in Singapore has become more important than ever. Singapore would have more advantage if more of its high-ability students are inclined towards career tracks that are keys to the nation's progress, one of which is the field of science and technology (Caleon, 2008).

1.4.4 AGENCY FOR SCIENCE, TECHNOLOGY & RESEARCH

One testimony of the Singapore government's commitment to Science and Technology is the hefty investment in the Agency for Science, Technology and Research (A*STAR), which aims to attract, train and nurture clinician-scientists and serves as a critical bridge linking basic research undertaken by A*STAR Research Institutes and clinical research programmes in Singapore's public hospitals, disease centres and the Universities.

Biopolis, which takes up 18.5 hectares and encompasses seven buildings, is highly regarded as the 'fourth pillar' of the economy. This massive research facility signifies one of the major international scientific recruitment drives ever undertaken in Southeast Asia. Many governments, life sciences industries, universities and research organisations are already putting major resources into life sciences and building up their capabilities, research and infrastructure in this area. Besides life sciences, the Singapore government is also fervently investing or trying to attract foreign investment in other scientific sectors like Engineering and Information Technology which are projected to continue to grow rapidly in the decades to come. Without a doubt, these massive investments will require a large pool of highly motivated and knowledgeable local and international doctoral students and scientists to fulfill the vision of turning Singapore into a major life science hub.

1.4.5 SCIENCE TALENTS IN SINGAPORE

Whilst it is vital to attract top internationally renowned scientists to Singapore to accomplish the above goal, it is just as imperative for the government to train local talent. Where and when should Singapore start the training of her future talents? Needless to say it is in the nascent stage of Science education - the primary school.

Educators agree that scientific literacy should be nurtured as early as possible (Bybee, 1997). Research has also found that positive attitudes towards Science at primary school were fundamental to pupils' later interest in Science, both in general and as a career (Smail 1993, as cited in Silver & Rushton, 2008). The Singapore Government is fully aware that betting on her human-capital is the way to go for the country's future.

With that in mind, the Ministry of Education has made it policy to always stay relevant to the ever changing world of Science and Technology with constant updating of the Science syllabus. Much has been done to educate young minds and their strategies have proven to be rather successful, judging from the string of accolades the Singapore students have achieved on the international arena. One such honour is the results released by the Trends in International Mathematics and Science Study, or TIMMS for short.

1.4.6 TRENDS IN INTERNATIONAL MATHEMATICS & SCIENCE STUDY (TIMSS)

The TIMSS developed and implemented at an International level by the International Association for the Evaluation of Educational Achievement (IEA), compare over time the Mathematics and Science knowledge and skills of fourth- and eighth-graders (primary four and secondary two respectively).

It shows the degree to which students have learned Mathematics and Science concepts and skills likely to have been taught in school. According to the TIMSS guidelines, they call for a minimum of 150 schools to be sampled per grade, with a minimum of 4,000 students assessed per grade.

In the TIMSS 2007 that involved 58 countries, Singapore with 6500 students taking part in the study was ranked in top positions for the fourth and eighth graders for both Science and Mathematics. From 1995 to 2007 for Science, the fourth graders made an improvement of 63 average points from 523 to 587; the United States decreased by 3 points from 542 to 539 points, while the United Kingdom moved from 528 to 542 points, an improvement of 14 points.

In the same study, Singapore also had the largest proportions of highly competent students who reached the advanced benchmark in Primary 4 Science (36%). The country's top 5% of students fared exceptionally well internationally, scoring the highest for Primary 4 Science (Average Score: 727). Singapore and Slovenia were the only two countries amongst the 58 countries with no significant difference in the scores between the male and female 4th graders. In the average science content and cognitive domain scores of fourth-grade and eighth-grade students, Singapore students took the first position for the two domains of Content (Life Sciences, Physical Science & Earth Science) and Cognitive (knowing, Applying & Reasoning). The closest competitor to Singapore was Taiwan. As for the eighth-grade students, Singapore students once again came in first for the average science content (Biology, Chemistry & Physics) and cognitive (knowing, Applying & Reasoning) domain scores, only Chemistry, Earth Science and Applying were second to Chinese Taipei.

1.4.7 ROLE OF A SCIENCE TEACHER

> "During the crucial formative period of children's lives, the school functions as the primary setting for the cultivation and social validation of cognitive competencies. School is the place where children develop the cognitive competencies and acquire the knowledge and problem-solving skills essential for participating effectively in the larger society. Here their knowledge and thinking skills are continually tested, evaluated, and socially compared. As children master cognitive skills, they develop a growing sense of their intellectual efficacy. Many social factors, apart from the formal instruction, such as peer modeling of cognitive skills, social comparison with the performances of other students, motivational enhancement through goals and positive incentives, and teachers' interpretations of children's successes and failures in ways that reflect favorably or unfavorably on their ability also affect children's judgments of their intellectual efficacy." (Bandura, 1994)

How is Singapore, a small country with a population of about five million people, able to instil science knowledge into their students so well as to beat participants from 57 other countries, achieving the highest percentage in the TIMMS 2007 Science table - particularly with their boys and girls having no significant difference in the scores?

Although it may be argued and a known fact that, in Singapore, parental or general societal pressure and expectations that children should work hard and do well at school does play a part in the outcome of the TIMMS results, students in other Asian counties like Taiwan, Hong Kong, Korea and Japan face the same pressure too.

One factor that could have probably made the difference is their Science teachers. Since Science Education has been established as a fundamental subject in the children's development, the role of Science teachers have become of paramount importance. There is evidence that there is a correlation between teacher self-efficacy, teacher performance and student achievement (Ashton, 1984; Gabel, Rubba & Franz, 1977).

It has been noted that the higher the level of teacher self-efficacy, the greater the accomplishments of students in these teachers' classrooms (Bandura, 1982).

The Singapore Ministry of Education strongly believes that teachers are one of the most important factors in Science education: "The teacher is the leader of inquiry in the Science classroom. Teachers of Science impart the excitement and value of Science to their students. They are facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Teaching and learning approaches centre around the student as an inquirer" (MOE, 2010).

Excellent primary teachers maintain a constructive Science classroom climate in which the students are motivated to learn (Anderson, 1989; Fraser, 1994; Tobin & Fraser, 1990, as cited in Mellado, Blanco & Ruiz, 1998). Good Science teachers ask questions that stimulate interest among the children. The questions posed are also related to the quality of teaching and can provoke responses of high cognitive level from students (Roth, 1996; Watt, 1996, as cited in Mellado et al., 1998). Another role of the teacher's is to constantly acquire adequate knowledge of the topic to be taught. With greater Science content knowledge, they are better at identifying key points, developing instructional representations and analysing student thinking (Hollon, Roth & Anderson, 1991) and help the children to explain observed phenomenon accurately.

Current Science teachers also play a vital role for future Science teachers. This is because the years spent in school and the experiences as students learning Science influence both the novice (Gustafson & Rowell, 1995; Young & Kellogg, 1993) and experienced primary teachers (Wallace & Lounden, 1992).

This will affect their professional future since many teachers use pedagogical methods that are very similar to those they preferred in their own teachers when they were students (Huibregtse, Korthagen, & Wubbels, 1994) or teach in the same way they themselves were taught (Tobin, Tippins, & Gallard, 1994, as cited in Mellado et al., 1998).

Simpson and Oliver (1990) noted that if primary teachers are not as interested in teaching Science as they are in other subjects, their pupils will probably not receive adequate backgrounds in Science during critical stages of learning. This could exacerbate negative attitudes towards Science amongst the students who could shun Science subjects eventually. This will result in only a small number of students leaving secondary school with a strong background in and commitment towards Science. Plummer (1981) warned that this vicious circle will continue into primary Science education where poor teaching disenchants the majority of girls who become teachers. As a result, it is important to explore primary teachers' confidence and attitudes to school Science and how it affects their pupils (Pell & Jarvis, 2003).

1.4.8 THE IMPORTANCE OF SCIENCE EDUCATION FOR CHILDREN

According to Lee, Tan, Goh, Chia, and Chin (2000), one of the goals of Science education is to develop the learners' ability to think critically, reason logically and be able to solve problems. Watters and Ginns (2000) stated that Science education plays a major role in the development of critical and informed citizens in a fast-changing technological society. They added that it must be made meaningful and useful for children of today so as to develop the understandings and habits of mind they need, to become compassionate human beings able to think for themselves and to face life head on. Ormerod and Duckworth (1975) emphasised the importance of the junior years, and the 8–13/14 years are critical for children's formation of attitudes to Science.

As such, Hodson and Freeman (1983) wrote that 'the image of contemporary science and of scientists which is presented to young children (under 12) is of great importance in forming their attitudes and determining their choices, as many pupils show an awareness of future careers before entry into secondary school' (Musgrove

& Batcock 1969; Blatchford 1992). Science in early childhood is of great importance for the development of children's scientific concepts as well as for many other aspects of their development.

Some scholars even backed the idea that Science should start in early childhood. Modern beliefs maintain that appropriate scientific work can and should begin in infant classes (Duckworth, 1996).

1.4.9 TEACHING AND LEARNING THROUGH INQUIRY

In the new MOE Science Syllabus Primary 2010, much emphasis has been put on the inculcation of the spirit of scientific inquiry, which is grounded in knowledge, issues and questions that relate to the roles played by science in daily life, society and the environment (MOE, 2010). MOE explains the aims of the new curriculum:

> "The science curriculum seeks to nurture the student as an inquirer. The starting point is that children are curious about and want to explore the things around them. The science curriculum leverages on and seeks to fuel this spirit of curiosity… The teacher is the leader of inquiry in the science classroom. Teachers of science impart the excitement and value of science to their students. They are facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Teaching and learning approaches centre around the student as an inquirer... To meet the learning styles of students offering Foundation Science, teachers should carry out the inquiry-based approach through hands-on learning, from concrete to abstract… students become engaged and excited about what they are studying and they then become motivated to learn. Teachers are also encouraged to use a variety of strategies to facilitate the inquiry process."

With the introduction of inquiry Science into the classroom, the role of the Singapore Science teacher has changed dramatically. The teachers become the leader of inquiry who impart the excitement and value of Science to their students. They become facilitators and role models of the inquiry process, and create a learning environment that will encourage and challenge students to develop their sense of inquiry. This means that Science teachers will have to be better prepared to meet such challenges. In other words, their self-efficacy for teaching Science has to be much higher than before. This current research becomes more important as it attempts to measure the self-efficacy of Singapore female teachers for teaching Science.

1.5 ATTITUDE OF TEACHERS & STUDENTS TOWARDS SCIENCE

1.5.1 ATTITUDE OF STUDENTS TOWARDS SCIENCE

Although Science has become so important for the students and the society, the attitude of students towards this subject has been rather unfavourable. The overloaded curriculum de-motivated students towards Science (Duggan & Gott, 2002). With each level they progress, the topics become more difficult than before and this accelerated the number of students shunning away from Science.

The pupils also saw Science as lacking relevance to everyday life (Duggan & Gott, 2002). For example, by the time American children reach middle school their attitudes toward Science have begun to decline (Johnson & Johnson, 1982). Smail (1993) advised about the adverse effects of such attitude on children that if they do not develop positive attitudes to Science and Technology in the primary years, there is little evidence to suggest that they will acquire them in secondary school and beyond.

Haladyna, Olsen and Shaughnessy (1982) identified the factors influencing pupils' attitudes to Science, and three content variables were identified: the student, the learning environment and the teacher. There are two variables namely exogenous and endogenous. Exogenous encompasses student gender and socio-economic status; they are located outside the institution of the school and are not under the direct influence of the school process. Endogenous variables, including teachers' characteristics, are within the influence of the school process and are therefore open to changes that can improve attitudes (Pell & Jarvis, 2003).

1.5.2 ATTITUDE OF TEACHERS TOWARDS SCIENCE

Are teachers culpable for the pupils' negativity towards Science since they are wholly responsible for their well-being in school? The answer is positive, for it is believed that teacher attitude affects the attitude and/or performance of students (Ramsey & Howe, 1969).

As early as the 1970s, elementary teachers had been known to have negative attitudes toward Science (Shrigley, 1974), did not care for science (Tilgner, 1990) and did not have confidence in their ability to teach Science (DeTure, Gregory & Ramsey, 1990). This in turn caused elementary teachers to avoid teaching Science to children (Czerniak & Chiarelott, 1990; Westerback, 1982, 1984) or spent less time teaching science as compared to other subjects (Good & Tom, 1985; Weiss, 1987; Westerback, 1984).

In a survey sponsored by the National Science Foundation, Weiss, Matti and Smith (1994), and Weiss, Banilower, McMahon and Smith (2001) reported respectively that in 1993 and 2000 with a probability sample of approximately 6,000 teachers throughout the United States, in self-contained elementary classes, grades 1-6, an average of only about half an hour per day (28 minutes in 1993 and 27 minutes in 2000) was spent on Science instruction compared to almost an hour per day (52 minutes in 1993 and 60 minutes in 2000) on Mathematics instruction, and roughly 70 minutes in 1993, and over 105 minutes in 2000 on reading/language arts instruction.

Nonverbal messages may also communicate that Science is not important or liked, especially if it is not taught on a regular basis (Riggs, 1991). The concern about Science teaching at the primary and elementary levels is not limited to the US – many researchers across three continents have established that teachers in these lower grades generally have poor attitudes towards Science and science teaching (Rice, 2005).

Weiss et al. (2001) reported that amongst the several subjects such as Science, Math, and other academic subjects that elementary teachers are assigned to teach, 76% of them reported feeling very well qualified to teach reading, about 60% felt very well qualified to teach Math and Social Studies, while only 29% felt very well qualified to teach Life Science. Fewer than 18 %t felt very well qualified in the physical sciences - an average of 24 % for Science overall.

1.6 IMPLICATIONS OF TEACHERS' NEGATIVITY TOWARDS SCIENCE

Teachers' negative attitudes and low confidence in the teaching of Science could be detrimental as they prevent new teachers from exploring better ways of instilling science knowledge and making the subject a fun one to learn. This could lead to the teachers relying heavily on textbooks, as evidenced in Glynn, Yeany and Britton's (1991) study that school Science curricula are mainly 'textbook-centred'. The textbook is usually accompanied by a large bulk of resource materials such as additional information, overhead transparencies, wall charts, cassette tapes, teaching kits, worksheets, exercises, suggested activities and experiments and the activity cards.

Besides this, there are also 'very useful' teachers' handbooks prepared by the publishers, which prescribe precisely how a concept should be taught (So, Tang & Ng, 2000). The reliance on textbooks during Science lessons is undesirable as it emphasises the learning of answers more than the exploration of questions, memory at the expense of critical thoughts, bits and pieces of information instead of understanding in context, recitation over argument and reading in lieu of doing (American Association for the Advancement of Science Report, 1989). These teachers would 'cover' the topic from a text and encourage children to 'learn' it (Murphy, Neil, & Beggs, 2007).

1.7 REASONS FOR PRIMARY TEACHERS TO SHUN SCIENCE

I have discussed the attitudes of teachers towards Science, which have been mostly discouraging - and its implications. In this section, I will list the teachers' reasons for avoiding teaching Science.

From his findings during interviews with elementary teachers, Scott (1988) listed the following points for many teachers to drop Science to a very low priority in their programmes: -

- Lack of appropriate published activities
- Inadequate time to gather together physical resources and organise Investigatory activities

- A lack of, or unfamiliarity with physical resources
- Lack of confidence to both organise practical experiences and to teach in areas where they did not feel confident
- Lack of confidence following a lesson failure and/or a poorly received piece of work
- Unfamiliarity with the requirements of the system's policy statement
- Dislike for school based curriculum inherited when they began their duty at that particular school

1.8 OBSTACLES FACED BY PRIMARY SCIENCE TEACHERS

Scott (1989) pointed out that the above factors have resulted in Science lessons being demoted to the sessions late in the day, being 'put off', receiving little preparation time, being allocated to relief teachers' being combined with another investigatory subject such as social studies, or worse, not being programmed at all. His findings are consistent with much earlier findings like that of Shrigley (1977) that hardware, preparation time, administrative restraints and assistance for preparation were major factors limiting Science teaching for some 450 teachers in the U.S.A.

Elementary school teachers needed help on how to teach Science more effectively (Harlen & Holroyd, 1997). For practical work, they needed more equipment and teaching materials. The shortage of adequate Science materials and equipment supposedly discourage in-service teachers from conducting hands-on Science (Weiss, 1994).

Teachers also claimed that they have had negative experiences with group work and classroom management when teaching Science (Goodrum, Cousins, & Kinnear, 1992).

The elementary curriculum is overloaded with a preponderance of non-curricular activities which take away from the time spent on teaching and learning Science (Plourde, 2002). Outside the classroom, the teachers needed time to reflect on their own teaching to see if the lessons had been effectively conducted (Lee et al., 2000).

Lee et al. (2000) reported that time was a major factor where Science-teaching was concerned in their research on Science teachers in Singapore. About two-thirds of the teachers surveyed indicated that problem-solving activities were time consuming. A similar percentage of the teachers also indicated that there were time constraints imposed by the schools' timetables and problem solving takes time. Some teachers pointed out that the number of periods for Science teaching was insufficient to include problem solving on a frequent basis. As such, demonstration and the expository teaching approaches were administered in their teaching. 85% of the teachers were pressurised to first cover content that would be tested in examination. Many teachers also indicated that they did not have enough time to prepare the materials for their Science activities and that the schools lacked support staff such as Science rooms / laboratory technicians.

Murphy et al. (2007) conducted telephone interviews with primary teachers and when the latter were asked an open question to suggest the main issues impacting on primary Science teaching, half of the teachers identified teachers' confidence and ability to teach Science as the number one issue.

This is followed by in order of priority:

- Lack of resources
- Lack of time for Science teaching
- Problematic content of the primary Science curriculum
- Large class sizes for Science and the lack of teaching assistants

They also found that younger teachers were less likely than their older counterparts to highlight a lack of confidence in primary Science as a major issue. Only 23% of younger teachers (in their 20s) responded that teachers' lack of Science knowledge/expertise/confidence/ training was an important issue. This was much less than teachers in the other age groups. Between 50% and 60% of teachers in their 30s, 40s, 50s and 60s highlighted it as a major problem. There was no considerable difference in the responses of female and male teachers, teachers who had or had not received professional development in Science or teachers of different year groups.

1.8.1 INADEQUATE SUBJECT MATTER KNOWLEDGE & PEDAGOGICAL KNOWLEDGE

In Shulman's (1986) theoretical framework, there are two forms of knowledge that teachers need to master. The first is subject matter knowledge and the second is pedagogical content knowledge. Shulman (1986) suspected that through the process of planning and teaching specific content, teachers would develop more powerful forms of subject matter knowledge. The growth of knowledge of how to teach their subject matter is a crucial aspect of teachers' knowledge development in their early years. Pedagogical knowledge, the second kind of content knowledge, goes beyond knowledge of the subject matter to the dimension of subject matter for teaching. Shulman (1986) explained the importance of Pedagogical Content Knowledge: "Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, example, explanations, and demonstrations-in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p. 203).

Teachers need a rich and deep understanding of their subject in order to respond to all aspects of pupils' needs (Buchmann, 1984). However, teachers time and again reported that they felt least qualified to teach Science amongst the four subject areas most often covered in elementary classrooms—reading/language arts, Mathematics, Science and Social Studies (Fulp, 2002; Weiss, 1994).

Primary school teachers themselves cited an inadequate Science background as one of the reasons for not teaching Science (Appleton & Kindt, 1999). Many pre-service teachers entered their student teaching semester with limited conceptual understandings of scientific ideas regardless of how many previous Science classes they had had (Riggs, 1991).

Even if they possess high school and college Science qualifications, Science teachers often lack fundamental understanding of many concepts found in state Science standards and elementary Science texts such as seasons, night and day, heat and temperature, the water cycle, etc. (Rice, 2005).

Even some of the Science taught at primary school was too difficult for the teachers, never mind the children (Murphy, Beggs, Hickey, O'Meara, & Sweeney, 2001). With little Science preparation, teachers develop a negative attitude toward Science and, therefore, avoid its teaching (Riggs, 1991).

1.8.2 SHORTAGE OF QUALIFIED SCIENCE GRADUATES IN EDUCATION

There has been a serious shortage of qualified Science teachers in the field of education in many countries (Wang, 2004). But where have those qualified Science graduates gone? According to Wang (2004), college students majoring in Science usually have far better opportunities than students of other majors to seek employment in business and industry, and command higher remuneration than that provided by teaching. For that reason, Science graduates tend not to choose teaching as a career (Dolton, 1990).

As shown in studies, most of the Science major graduates are men who are unlikely to choose teaching as a career. Farquhar (1997) believes that the low social status of the primary teacher, poor wages in relation to the work performed, limited career path for those not seeking administrative roles, the labelling of male primary school teachers as homosexual or not 'real men', current media spotlight on allegations of child sexual abuse, fear of being labeled as a paedophile and the impact of child protection policies in schools, as reasons for men to avoid teaching in primary schools.

That left most of the women who had majored in other disciplines and a very small percentage of the women who majored in Science to join teaching in primary school as a career. Women's negativity towards Science and why they shunned Science will be discussed on page 31.

1.8.3 CONSEQUENCES OF DEFICIENCIES IN SCIENCE KNOWLEDGE

If teachers possess deficiencies in content knowledge for topics to be taught it can cause a whole gamut of problems. These teachers were seen to interact less, ask fewer questions overall and about causes in particular (Newton & Newton, 2001).

Primary teachers' low level of knowledge of Science is also a hindrance to its effective teaching (Abell & Roth, 1992) and they have difficulty in carrying through educational changes (Grimellini & Pecori, 1988). They also avoid teaching topics they do not know sufficiently well (Smith & Neale, 1991) and depend more upon the textbook for both instruction and evaluation, and memorizing information (Mellado et al., 1998).

These teachers whose understanding of Science is not good, he or she would 'cover' the topic from a text and encourages children to 'learn' it (Murphy et al., 2007). They would normally keep to what they deemed as 'safe' teaching methods, which impoverished children's learning opportunities (Harlen, 1995, as cited in Murphy et al., 2007). They relied heavily on work cards with step-by-step instructions, gave emphasis to expository teaching, and kept away from using any equipment that might go wrong (Harlen, 1995, as cited in Murphy et al., 2007).

1.8.4 ALTERNATIVE CONCEPTIONS OF SCIENCE

Students have many conceptions and / or interpretations of scientific phenomena, and these conceptions and interpretations are termed as 'alternative conceptions' (Pfundt & Duit, 1998, as cited in Boo, 2006). They are misconceptions or views of Science that are at odds with concepts currently accepted by the community of scientists (Boo, 2007). Inaccurate representations of conceptual relationships, alternate conceptions or misconceptions create more mistakes (Strike, 1983).

As such, a student's preconceptions or existing alternate conceptions hinder effective concept learning in the future and this has been shown in a number of studies (e.g., Cachapuz & Martins, 1987, as cited in Boo, 2007).

Misconceptions are very persistent once established in primary children (Pine, Messer & St. John, 2001). What is alarming is that not only do primary school teachers feel inadequately prepared to teach Science; but that it is not unusual to find that they have some of the same erroneous or alternative conceptions as their students (Gooday & Wilson, 1996; Schoon, 1995) and the children (Wandersee, Mintzes & Novak, 1994). It has been found that students have acquired those misconceptions from teachers and student teachers (Osborne & Cosgrove, 1983).

Research has found that teachers who have completed high school and college Science requirements are found to be lacking in basic understanding of many concepts that are found in state Science standards and elementary Science texts. These concepts are not obscure or complex concepts, but some of the basic building blocks of science knowledge (Parker & Heywood, 1998).

1.8.5 MISCONCEPTIONS IN SCIENCE EXAMINATION QUESTIONS

Although there is no research on Singapore teachers' imbedded misconceptions, Boo (2006) in his scrutiny of more than 100 sets of Singapore primary Science examination papers found considerable misconceptions held by the Science question setters (school teachers) concerning basic physical Science phenomena, even in basic topics such as boiling point and freezing point, evaporation and condensation, etc.

Boo (2007) also found question setters' or teachers' misconceptions concerning some key primary school level Biological Science concepts in the areas of cells, plant and animal systems and functions based on his scrutiny of more than 200 sets of primary Science examination papers in schools.

The concepts involved in the test item are a recurrent source of problems to many question setters. Boo (2007) believed that his findings supported the suggestion by researchers (such as Osborne & Cosgrove, 1983; Bar & Travis, 1991) that teachers can be the source of many of the misconceptions held by students. He advised that such erroneous items are also likely to perpetuate the students' misconceptions which are resistant to change or, worse, introduce misconceptions where formerly correct conceptions were held. These misconceptions persist even with formal Science instruction.

Boo (2007) added that whilst some of the misconceptions may be due to poor item crafting - particularly the failure to see all the possible perspectives that the pupils might see, it must be assumed that many of them are deeply held and will therefore be reflected in classroom instruction.

1.8.6 WAYS TO REMOVE MISCONCEPTIONS

One of the best methods to address the above issue is to encourage Science teachers to actively engage in professional development. But how successful can this process be?

Research has shown that some teachers feel confident teaching abstract concepts to primary children but when diagnostically tested share many of the misconceptions and alternative frameworks of their pupils. This was also true for the research Jarvis and Pell (2004) conducted. Teachers who went through an intensive Science based professional development programme which aimed to improve primarily their knowledge of Science concepts for certain topics which primary teachers have difficulty with, found their enthusiasm about teaching Science to their classes improved as a result of this programme. Unfortunately though, a few of them still held on to some misconceptions. The above reports show that the misconceptions that the Science teachers hold are perpetual and difficult to remove.

This does not however demonstrate that professional development is ineffectual because misconceptions will of course take time to change. To be competent and knowledgeable, the teacher must undergo comprehensive training and continue to learn throughout his or her teaching career (Kofi, 2007). More on professional development will be discussed on page 56.

1.8.7 WOMEN & SCIENCE

Many studies have been conducted around the relationship between gender and Science. As early as the 1970s males had been found to have more positive attitudes towards Science teaching than females (Taiwo, 1980). Males were better when controlling for previous exposure to Science education - an individual's gender "is related more to the degree of favorable of one's attitude toward science teaching than to previous exposure to science education" (Riggs, 1991, p. 319).

Gender differences in academic interest and cognitive and interaction style are well studied (Arroyo, Murray, Woolf & Beal, 2003). There is support for the theory that females possess more Science anxiety than males (Udo, Ramsey & Mallow, 2004), and boys show a greater overall interest in Science topics than girls (Dawson, 2000). Boys are consistently reported to have participated in more classroom and extra-curricular Science activities than do girls (Jovanovic & Dreves, 1998, as cited in Ferreira, 2003) and display more positive attitudes towards Science than girls (Reid and Skryabina (2003). The above trends could probably be due to the structure of Science courses that have been rather male-orientated with boats, car, parachute, (Hodson & Freeman, 1983). For example, a speedboat can be used to illustrate that objects with streamlined body shapes can reduce water resistance, while a parachute can be used to illustrate the relationship between the area of exposed surface and air resistance.

The experiences that women went through in school, at home and at work greatly affected their perceptions of Science. Their peers, parents, teachers and relatives had much influences over students' enrolment choices (Dalgety & Coll, 2004). In a study investigating gender and Physics, Reid and Skryabina (2003) discovered that females were drawn to themes that had high social relevance, whilst males were more attracted to those themes that were perceived to have a high mechanical or practical relevance.

Jones, Howe and Rua (2000) argued that there remains a gender difference in Science experience, attitudes and perceptions of Science courses. For instance, Kahle, Matyas and Cho (1985) found that high school boys were significantly more likely than girls to have read Science articles in magazines, talked about Science with friends, or engaged in Science related hobbies. Jones et al. (2000) also found boys were more likely than girls to have extracurricular experience with Science related artefacts (such as microscopes) and were more likely to endorse interest in Science related hobbies.

In Jones et al.'s (2000) study on the interests, attitudes, and experiences related to Science in 437 sixth-grade American students from different areas and socio-cultural backgrounds. The students were asked to report on the frequency of their involvement in Science-related experiences, and whether or not they were interested in different Science topics.

The authors reported that males were attracted by topics such as atomic bombs, atoms, computers and technology (e.g., the application of mechanics on cars and flight) and they often reported using tools and instruments (such as batteries, electric toys, or microscopes). Girls were mainly interested in topics related to Biology (such as animal communication, healthy diet), or in topics with an aesthetic dimension (e.g., rainbows), while their typical out-of-school, Science-related experiences include bread-making, observing birds and stars, knitting, or planting seeds. Moreover, the girls' scientific interests and experiences often had a powerful affective interpersonal dimension; that is, they were strongly influenced by the presence of other people who they loved and admired.

Based on Miller's (2006) finding, females simply do not find Science interesting or relevant to their life goals and in fact their dislike is not linked to a perception that it is too hard or not fitting the female gender role. High-school females who plan to continue their study of Science also follow a route that differs from that of boys. The girls' interest in Biology and their desire to help people may lead them to medicine or other health professions rather than Science per se. The boys on the other hand, they aim towards applied Science careers in engineering, computer science, and medicine. This is not generally with the primary motivation of helping people. (Miller, 2006)

There are however other researchers who found that girls had higher self-efficacy beliefs and attainment in Science than boys with their sample of 262 7th Grade pupils (Britner & Pajares, 2001). With regards to gender differences in self-efficacy, girls were found to perform significantly better than the boys on the Science performance measure (Webb-Williams, 2006).

1.8.8 BARRIERS FACED BY SINGAPORE SCIENCE TEACHERS

More than 15 years ago, Chin, Goh, Chia, Lee and Soh (1994) reported that whilst teaching Science, Singapore pre-service teachers preferred the expository approach instead of problem-solving teaching approach. The problems they faced while conducting problem-solving included their lack of academic and pedagogical content knowledge and their strong belief in maintaining control of students' learning activities. The ability of their students, their concern about classroom management problems and contextual factors operating within the school system were also a factor. The latter is a result of the expectations and beliefs of their co-operating teachers and principals, the accountability for pupils' results, time constraints and the difficulty and inconvenience in obtaining appropriate resources. Within those constraints they tried covering prescribed content in the allocated time and drilling their students in getting correct answers and satisfactory grades, which was perceived as tangible evidence of success and good teaching.

1.9 SIGNIFICANCE OF THE STUDY

Throughout the process of reviewing studies conducted on women in Science, it was revealed that female primary teachers possess a negative attitude towards Science, a subject deemed too 'difficult' or 'uninteresting' to them. They often lacked basic understanding of many concepts that appeared in the country's state Science standards and primary Science textbooks.

As a result alternative conceptions or misconceptions began to take shape in them which inadvertently affected the quality of their teaching. They did not have confidence in their ability to teach Science and hence avoided or spent little time on this subject. They also had an inadequate Science background and a poor attitude towards Science and Science teaching. They felt the least qualified to teach Science. Females were found to be avoiding Science and Technology when it came to choosing their major in schools and their careers and they possessed more Science anxiety than males.

Self-efficacy expectations are major determinants of whether a person will attempt a task, how much effort will be expended and how much effort will be displayed in the face of obstacles (Bandura, 1977). Hence, Smolleck and Yoder (2006) offered a possible reason for their negativity toward Science; they believed the low self-efficacy of the teachers was the reason for teachers to devote less instructional time to teaching Science.

Research has also indicated the importance of self-efficacy in shaping elementary teachers' likelihood to teach Science (Weld, & Funk, 2005). Teachers with high efficacy beliefs contribute to stronger student achievement than teachers with lower teacher efficacy (Goddard, Hoy, & Hoy, 2004). Primary school teachers cited their inadequate Science background as the reason for not teaching Science and this could undermine the students' achievements in Science.

In the introductory part of this paper, I have reported that women made up a large proportion of the primary teacher population in Singapore just like any other country. From the extraordinary achievement of the Singapore 4^{th} graders in the TIMMS survey 2007 and the findings that teachers' own self-efficacy beliefs influence both their own practice and their students' self-beliefs and achievement (Ashton & Webb, 1986), would there be any significant difference between the self-efficacy of Singapore female primary Science teachers and their male counterparts?

There appeared to have been hardly any investigation on the self-efficacy of Singapore primary school teachers with even fewer investigations on possible gender differences in Science self-efficacy. There was a report of barriers (Chin, et al., 1994) facing the Singapore Science teachers that it took place sixteen years ago, but there had been no research on the enablers that made Singapore female teachers proficient Science teachers.

Are the Singapore teachers still facing the same barriers they encountered in 1994? Science has become one of the most important subjects in the Singapore primary school curriculum. With more information on the Science self-efficacy of the teachers and also on the enablers and barriers they face while teaching Science, it would enhance the efforts to support the educators and students in developing and achieving their fullest potential in Science. The above provided the basis for my research which sought to extend findings in Science self-efficacy, in particular the Singapore female primary Science teachers, and the current enablers and barriers they face in the Science classroom.

1.9.1 RESEARCH QUESTIONS

The primary aim of this thesis is:

- What is the Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) of Singapore female primary teachers when compared to their male counterparts?

- To gain a clear outline of what barriers and enablers Singapore female primary teachers identify in the effective teaching of Science, and highlight the problem(s), if any, to the heads of science educators in the Ministry of Education (MOE) / National Institute of Education (NIE).

- To suggest ways to improve the self-efficacy of female science teachers

1.10 CHAPTER SUMMARY

In this chapter, I have discussed the importance of Science Education in Singapore. The government is committed to turning the country into a Science hub and this is shown in their setting up of A*STAR and other hefty investments in its infrastructures. With this unprecedented investment, talents in Science must be fostered to lead what has been called the next technological revolution.

So far in the last ten years, the Ministry of Education has done an exceptional job in training the teachers and students judging from the accolades Singapore students have achieved in the international arena.

I have discussed the importance of Science education for children and the role teachers play in nurturing young talents. However, the attitude of teachers and students towards Science according to reports from other countries has been unfavourable. Teachers and students found the subject to be too difficult for them to teach and learn respectively. School teachers who on the most part are not Science major graduates attributed their reasons for shunning the subject to their inadequate Science background. Such deficiency in Science has led to the formation of alternative concepts which could potentially lead to the teacher teaching erroneous Science concepts to their students.

Women were found to hold negative views on practically all areas of Science. With this negative attitude towards Science teaching, it led me to the question: 'What is the self-efficacy of Singapore female primary Science teachers when compared to their male counterparts?' 'What are the barriers and enablers that female teachers identify in the effective teaching of Science?'

Because student performance and teachers' self-efficacy towards teaching a subject is correlated, the main aim of this thesis attempts to answer those questions.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In Chapter 2, I conducted a literature review on the theories relating to self-efficacy and its criticisms, teacher efficacy (high and low efficacy teachers), Science teacher self-efficacy and women's self-efficacy. There is much confusion amongst the constructs of self-efficacy, self-concept, self-esteem and self-confidence, perceived control and locus of control so their differences will also be addressed here**.** This is followed by the four possible interventions that Bandura (1986) suggested to increase self-efficacy; they are: enactive mastery experience, vicarious learning, verbal persuasion and physiological and affective states. In order to achieve the primary aim of this thesis which is to measure the Science self-efficacy of the female teachers against their male counterparts, I reviewed the different instruments used for measuring self-efficacy.

In the foreword of their book, 'Self-efficacy Beliefs of Adolescents', Pajares and Urdan (2006) stated the importance of self-efficacy: "The introduction of the psychological construct of self-efficacy is widely acknowledged as one of the most important developments in the history of psychology. Today it is simply not possible to explain phenomena like human motivation, learning, self-regulation, and accomplishment without discussing the role played by self-efficacy belief" (p. ix).

2.2 DEFINITION OF SELF-EFFICACY

2.2.1 ALBERT BANDURA

Self-efficacy is grounded in a larger theoretical framework known as social cognitive theory, which suggests that human achievement depends on interactions between one's behaviours, personal factors such as thoughts and beliefs and environmental conditions (Bandura,1986, 1997, as cited in Schunk & Pajares, 2001).

In the fields of self-efficacy, Albert Bandura has been widely recognized as the authority and the most widely cited scholar.

Bandura, (1986, 1997) defined self-efficacy as an individual's judgment of their capability to organize and execute the courses of action required to attain designated types of performances. It is a future-oriented belief. It is not so much if one will gain a benefit from performing a task, but rather if the task itself can be successfully completed. Self-efficacy expectations are major determinants of whether a person will attempt a task; how much effort will be expended, and how much effort will be displayed in the face of obstacles (Bandura, 1997).

Bandura (1977) added that people with high self-efficacy choose to perform more challenging tasks. They set themselves higher goals and stick to them. Actions are pre-shaped in thought, and people anticipate either optimistic or pessimistic scenarios in line with their level of self-efficacy. Once an action has been taken, high self-efficacious persons put in more effort and persist longer than those who are low in self-efficacy. When setbacks occur, they recover more quickly and maintain the commitment to their goals. Self-efficacy also allows people to select challenging settings, explore their environments, or create new environments.

The apparent dynamic is that self-efficacy beliefs are "not simply inert predictors of future behavior", but that those with more efficacious beliefs "make things happen" (Bandura, 1989, p. 731, as cited in Lorsbach & Jinkins, 1998). Hence, negatively, people with low sense of efficacy will shy away from difficult tasks; have low aspirations and a weak commitment to goals.

2.2.2 DALE SCHUNK

Another leading researcher on self-efficacy, Schunk (1985) has another definition for self-efficacy: "[It] refers to personal judgments of performance capabilities in a given domain of activity that may contain novel, unpredictable, and possibly stressful features" (p.208). Efficacy beliefs also help determine how much effort people will expend on an activity, how long they will persevere when confronting obstacles, and how resilient they will be in the face of adverse situations (Schunk, 1981; Schunk & Hanson, 1985; Schunk, Hanson, & Cox, 1987). Efficacy beliefs also influence the amount of stress and anxiety individuals experience as they engage in an activity (Pajares & Miller, 1994, as cited in Pajares & Schunk, 2001).

Schunk (1981) was one of the earliest self-efficacy researchers to apply Bandura's self-efficacy theory to the problem of children's academic achievement in mathematics. He showed that efficacy perceptions are among the most important of all of the possible factors that lead to achievement in mathematics. He added that having high self-efficacy beliefs sustains task involvement, but a lower sense of efficacy leads to less persistence, which lowers achievement. Higher self-efficacy leads to the behaviors that are probably most consistent with success in school—trying and persevering. These behaviors according to him are, in fact, antecedent, or prerequisite, to successful performance in school.

2.2.3 OTHER SELF-EFFICACY RESEARCHERS

There are many self-efficacy researchers but most of them tend to point out the same five key features (e.g. Pajares & Miller, 1994, Jinks & Morgan, 1999, and Zimmerman, 1995).

Webb-Williams (2006) gave a summary of the five features: "First, it is an assessment of competence to perform a task not a judgment of personal qualities. Individuals are asked to judge how well they can perform given tasks, they are not asked about their personality traits, physical features or how a task makes them feel or think. Second, self-efficacy is domain-specific. Individuals can be highly efficacious in one domain (e.g. numeracy) but express low self-efficacy beliefs in another (e.g. literacy). Third, it is context-dependent. The execution of a task can be influenced by things such as competition, physiological state and environment. As such efficacy beliefs are influenced by the surrounding circumstances. For example, self-efficacy beliefs may differ between those children in competitive classrooms and those in more co-operative environments. Fourth, self-efficacy is measured before the task is performed. Thus it reflects one's perception of capability in light of the task demands rather than how one feels having completed the activity. Fifth, self-efficacy measurement does not depend on normative data. Self-efficacy questionnaires require respondents to rate their level of certainty about their own ability to perform a task without making reference to the performance of others."

2.3 CRITICISMS OF BANDURA'S SELF-EFFICACY THEORY & ITS MEASUREMENT

Marzillier and Eastman (1984) have been critical both conceptually and methodologically of Bandura's self-efficacy theory. They argued that the "theoretical construct of self-efficacy as presented by Bandura is ambiguous and despite his claims to the contrary, cannot be understood without reference to considerations or outcome… the experimental studies carried out by Bandura and his colleagues on self-efficacy can be most simply interpreted as indicating that people can successfully predict their future behaviour on discrete and circumscribed tasks provided that they have sufficient information to appraise their likely performance, and the outcomes for their performance are limited… self-efficacy theory oversimplifies the variables involved in behavior change. In particular, Bandura has failed to credit the importance of outcome expectations in his analyses; indeed, he suggests that expectations of outcome form the central and unifying construct in explaining the effectiveness of all forms of psychotherapy, thereby relegating other variables such as expectations of outcome to subsidiary roles… this is not a tenable or, indeed, credible analysis of therapeutic change" (p. 226 & 227). Marzillier and Eastman (1984) further argued that there remain problems both at the theoretical and the methodological levels with self-efficacy theory. Some of their concerns include: the difficulty of defining self-efficacy theory without reference to outcome considerations; and the methodology used by Bandura in the assessment of self-efficacy.

2.3.1 SELF-EFFICACY & SPECIFICITY OF MEASUREMENT

According to Webb-Williams (2006), there has been a debate within the literature regarding the optimal level of specificity of measures for self-efficacy. Scholars debated should the measures be general, domain-specific or task-specific.

Individuals need to make judgments about their capabilities without reference to a particular task or activity if general measures are involved. However, this, according to Pajares (1996a) means that de-contextualized global scores of self-efficacy which reflect a general personality trait are provided rather than self-efficacy as a context-specific judgment.

Indeed, General measures would also violate the basic assumption of the multidimensionality of self-efficacy beliefs, and hence, it is an inappropriate measure to use in tests of self-efficacy theory, nor do they have much predictive utility (Bandura, 1997). Webb-William (2006) would argue that domain-specific measures are therefore potentially more explanatory than general measures, but he pointed out Pajares' (1996a) assertion that task-specific measures are superior since in some domains distinct skills are required in each sub-domain.

An example was quoted for use in education. For mathematics, different skills are required to do fractions, subtraction, division, long multiplication, to use a calculator, or to do calculus. Hence, Webb-William (2006) argued that measures for self-efficacy do not need to be so specific that they lose their practical relevance. Researchers should avoid either highly general or highly specific measures (Tschannen-Moran & Hoy, 2001).

2.4 DEFINITION OF SELF-EFFICACY, SELF-CONFIDENCE, SELF-ESTEEM, SELF-CONCEPT, PERCEIVED CONTROL & LOCUS OF CONTROL

In the course of explaining to the teacher participants about the goals of this research, many did not completely understand the construct 'self-efficacy' and mistook the term as parallel to other constructs such as self-concept, self-esteem, self-confidence, perceived control and locus of control. Per se, the definitions need to be carefully defined to the participants so that there would not be any confusion that could jeopardise the result of this study. I will now proceed to define the differences of those motivational constructs.

2.4.1 SELF-CONFIDENCE

The distinction between self-efficacy and confidence is explained by Bandura (1997): "It should be noted that the construct of self-efficacy differs from the colloquial term 'confidence.' Confidence is a nondescript term that refers to strength of belief but does not necessarily specify what the certainty is about. I can be supremely confident that I will fail at an endeavor. Perceived self-efficacy refers to belief in one's agentive capabilities that one can produce given levels of attainment. A self –efficacy assessment, therefore, includes both an affirmation of a capability level and the strength of that belief. Confidence is a catchword rather than a construct embedded in a theoretical system. Advances in a field are best achieved by constructs that fully reflect the phenomena of interest and are rooted in a theory that specifies their determinants, mediating processes, and multiple effects. Theory-based constructs pay dividends in understanding and operational guidance. The terms used to characterize personal agency, therefore, represent more than merely lexical preferences" (p. 382).

2.4.2 SELF-ESTEEM

Whites (1963) gave us an explicit theory of self-esteem: "Self-esteem … has its taproot in the experience of efficacy. It is not built merely on what others do or what the environment provides. From the very start it is based on what one can make the environment provide… the feeling of efficacy is regulated by the success or failures of his efforts, for he has no knowledge of what else may be affecting the environment's response. From this point onward self-esteem is closely tied to feelings of efficacy and, as it develops, to the more general cumulative sense of competence" (p.134). Coppersmith (1967) defines self-esteem as "the evaluation which the person makes and customarily maintains with regards to himself: it expresses an attitude of approval or disapproval, and indicates the extent to which the individual believes himself to be capable, significant, successful, and worthy. In short, self-esteem is a personal judgment of worthiness that is expressed in the attitudes the individual holds towards himself" (p. 4-5). Rosenberg (1965) offers another definition for self-esteem as: "a positive or negative attitude toward a particular object, namely, the self… High self-esteem, as reflected in our scale items, expresses the feeling that one is "good enough." The individual simply feels that he is a person of worth; he respects himself for what he is, but he does not stand in awe of himself nor does he expect others to stand in awe of him. He does not necessarily consider himself superior to others" (p. 30-31).

2.4.3 SELF-CONCEPT

It is not easy to make a clear and convincing distinction between beliefs of self-concept and self-efficacy (Bong & Skaalvik, 2003). Self-concept is defined as an organised schema that contains episodic and semantic memories about the self and controls the processing of self-relevant information" (Campbell & Lavallee, 1993, p.4), while Rosenberg (1979) defined it as "the totality of the individual's thoughts and feelings having reference to himself as a n object" (p.7).

Self-concept is formed through experiences with the environment and is influenced especially by environment reinforcements and significant others (Shavelson, Hubner & Steanton, 1976). Shavelson et al. (1976) provided a similar definition of self-concept that formed the theoretical foundation of contemporary self-concept research: "In very broad terms, self-concept is a person's perception of himself. . . . We do not claim an entity within a person called "self-concept." Rather, we claim that the construct is potentially important and useful in explaining and predicting how one acts. One's perceptions of himself are thought to influence the ways in which he acts, and his acts in turn influence the ways in which he perceives himself. . . . Seven features can be identified as critical to the construct definition. Self-concept may be described as: organized, multifaceted, hierarchical, stable, developmental, evaluative, and differentiable" (p. 411).

2.4.4 PERCEIVED CONTROL

According to Pajares and Schunk (2001), the notion of perceived control also differs from self-efficacy. People who believe they can control what they learn and perform are more apt to initiate and sustain behaviours directed toward those ends than are individuals who hold a low sense of control over their capabilities (Bandura, 1997). Perceived control is generic; thus, it is meaningful to speak of perceived control over learning or performing and over outcomes. Further, perceived control is only one aspect of self-efficacy. Other factors that influence self-efficacy include perceptions of ability, social comparisons, attributions, time available, and perceived importance. People may believe they can control their use of learning strategies, effort, and persistence, yet still hold a low sense of self-efficacy for learning because they feel that the learning is unimportant and do not want to invest time in it.

2.4.5 LOCUS OF CONTROL

Bandura (1997) pointed out that here is also a distinction between self-efficacy and Rotter's (1966) internal-external locus of control. According to Tschannen-Moran et al. (1998), Bandura had presented data that showed that perceived self-efficacy and locus of control are basically not the same phenomenon measured at different levels of generality. He added that beliefs about whether one can produce certain actions (perceived self-efficacy) are not the same as beliefs about whether actions affect outcomes (locus of control). In reality both bear little or no empirical relationship to one another. In addition, Bandura emphasized that perceived self-efficacy is a strong predictor of behavior, whereas locus of control is typically a weak predictor.

Rotter's scheme of internal-external locus of control is basically concerned with causal beliefs about the relationship between actions and outcomes, not with personal efficacy. An individual may believe that a particular outcome is internal and controllable—that is, caused by the actions of the individual—but still have little confidence that he or she can accomplish the necessary actions.

2.5 EDUCATIONAL IMPLICATIONS OF SELF-EFFICACY

2.5.1 PERSONAL SELF-EFFICACY & OUTCOME EXPECTANCY

The construct of self-efficacy beliefs consists of the two dimensions: personal self-efficacy and outcome expectancy (Bandura, 1997). This theory is based on two components. Personal self-efficacy is a judgment of one's ability to organize and execute given types of performance, while outcome expectancy is a judgment of the likely consequence such performances will produce (Bandura, 1997). People develop a generalised expectancy about action-outcome contingencies through life experiences (outcome expectancy). Then they develop a more personal belief about their own ability to cope (self-efficacy). In cases where both self-efficacy and outcome expectancies vary, behaviour can be predicted by considering both factors. Research on self-efficacy pertaining to education suggests that this construct is a powerful predictor of the direction of teacher change (Woolfolk & Hoy, 1990).

On the other hand, Bandura argued that self-efficacy is a situation specific determinant of behaviour, and not a global personality trait. As a result, a teacher's overall level of self-efficacy may not properly reflect the individual's beliefs about his ability to implement effective programmes in specific subjects such as science.

2.6 DEFINITIONS OF TEACHER EFFICACY

2.6.1 TSCHANNEN-MORAN AND WOOLFOLK

Tschannen-Moran and Woolfolk (2001) defined teacher efficacy as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (p.783). Teacher efficacy is a self-perception, not an objective measure of teaching effectiveness (Ross & Bruce, 2007).

Tschannen-Moran, et al. (1998) explored virtually all the works and studies dated between 1974 and 1997 (articles, conference papers, and books) of researchers that used the term teacher efficacy in their studies and the different scales designed to measure teacher efficacy. They reported that based on the work of Rotter (1966) as a theoretical base, the RAND researchers were the first to conceive teacher efficacy which is the extent to which teachers believed that they could control the reinforcement of their actions, that is, whether control of reinforcement lay within themselves or in the environment.

They found that student motivation and performance were assumed to be significant reinforcers for teaching behaviors. Woolfolk and Hoy (1990) considered teacher efficacy as one of the few teacher characteristics that consistently relates to teaching and learning. There is correlation between teacher self-efficacy, teacher performance and student achievement (Ashton, 1984; Gabel et al., 1977), i.e. the higher the level of teacher self-efficacy the greater the accomplishments of students in these teachers classrooms (Bandura, 1982; Ashton, 1984).

2.6.2 ALBERT BANDURA

Bandura (1977) came out with the conceptual strand of theory and research identifying teacher efficacy as a type of self-efficacy - a cognitive process in which people construct beliefs about their capacity to perform at a given level of attainment. He added that teacher efficacy is a situation-specific and even subject-specific construct (Bandura, 1986).

This means that teachers would not necessarily feel uniformly efficacious for all teaching situations. Because efficacy is context specific, teachers may on one hand feel efficacious for teaching particular subjects to certain students in specific settings but on the other hand they can be expected to feel more or less efficacious under different settings (e.g. different subjects, different class, different level, high/low ability students, etc.) (Bandura, 1977). That is to say, teachers who are highly efficacious in an English lesson might not be as confident in a Science lesson (Palmer, 2006).

2.7 CHARACTERISTICS OF HIGH & LOW EFFICACY TEACHERS

2.7.1 ALBERT BANDURA & OTHER RESEARCHERS

Researchers have conducted many studies on high and low efficacy teachers. The following are works of different researchers on the characteristics of high and low efficacy teachers.

Bandura (1997) found that teachers who have a high sense of self-efficacy have a strong commitment to teaching, tend to regard learning problems as surmountable, make extensive efforts to motivate students, devote more class time to academic work, provide students with guidance and praise for their accomplishments, and in general are associated with higher levels of student achievement.

On the other hand, teachers with low self-efficacy spend less time on instruction, do not persevere when students experience difficulties, have an authoritarian approach, make little effort to motivate students and have a weak commitment to teaching the subject matter (Bandura, 1997).

He further added that teachers who were highly efficacious were also found to be more likely to use open-ended inquiry and student-directed teaching strategies, whilst teachers with a low sense of self-efficacy were more likely to use teacher-directed teaching strategies such as lecture and reading from the text.

Low self-efficacy does not only affect an individual teacher performing his or her work. According to Tschannen et al. (1998), a low sense of efficacy can be contagious among a staff of teachers, creating a self-defeating and demoralizing cycle of failure. Low teacher efficacy leads to low student efficacy and low academic achievement, which in turn leads to further declines in teacher efficacy (Bandura, 1997). Self-efficacy is contagious not only amongst the teacher's colleagues but students can easily 'catch' a teacher's own sense of confidence (Parajes, 2006).

Ross (1998) saw high efficacious teachers trying harder and using management strategies that stimulate student autonomy. They are also more likely to be effective in their classrooms by displaying enthusiasm for teaching, being open to students' ideas, and using innovative instrumental methods that reflect their instruction (Chen, 2006). The same teachers tend to create environments to achieve learning goals (Lorsbach & Jinks, 1998) and use less criticism (Pajares, 2002).

Highly self-efficacious teachers view student failure as an incentive to greater teacher effort rather than concluding that the causes of failure are beyond teacher control and cannot be reduced by teacher action (Ross & Bruce, 2007).

Schriver & Czerniak (1999) reported that low self-efficacy teachers expect low-achieving students to fail, expressing no surprise when their expectations came true, and taking no responsibility for the academic failures of their students. On the other hand, highly self-efficacious teachers believed that they could reach their low-achieving students and overcome the problems of students. They saw it as their responsibility to help these students overcome their problems and took pride in their ability to teach these students. They believed that disruptive behavior could be avoided if teachers made clear and fair rules, enforced them consistently, and established friendly relationships with students. The students of such high efficacious teachers have demonstrated to have more positive attitudes and achieved higher performance levels on achievement tests (Riggs, 1991)

Allinder (1994) found that Personal Teaching Efficacy (PTE) was linked to instructional experimentation, including willingness to try a variety of materials and approaches, the desire to find better ways of teaching, and implementation of progressive and innovative methods (as measured on the Teacher Characteristics Scale; Fuchs, Fuchs, & Bishop, 1992). High-efficacy teachers with high scores on both the PTE and GTE (General Teaching Efficacy) factors, were less likely to criticise a student for an incorrect response and more likely to persist with a student in a failure situation. These teachers were more likely to divide the class for small group instruction, instead of instructing the class as a whole (Tschannen-Moran, 1998). The levels of organization, planning, and fairness a teacher displayed, as well as clarity and enthusiasm in teaching, were also related to PTE. GTE was related to clarity and enthusiasm in teaching (Tschannen-Moran, 1998).

2.7.2 ASHTON'S 8 DIMENSIONS ON HIGH &LOW EFFICACY TEACHERS

From the analysis of Thematic Apperception Test-type responses of middle school teachers, Ashton (1984) identified 8 dimensions that distinguished the high from the low efficacy teachers:

- **A sense of personal accomplishment –** Teachers with a high sense of efficacy believe that the work with their students is important and meaningful and that they have a positive influence on student learning. Whereas those with low sense of efficacy feel frustrated and discouraged about teaching.

- **Positive Expectations for student behavior and achievement –** Teachers with a high sense of efficacy expect their students to progress and most of the time find that students fulfill their expectations. On the other hand, those with low sense of efficacy expect their students to fail, to react negatively to their teaching effort, and to misbehave.

- **Personal Responsibility for student learning –** Teachers with a high sense of efficacy believe that it is their responsibility to see that children learn and when their students experience failure, they examine their own performance for ways they might have been more helpful. Those with a low sense of efficacy shift the responsibility for learning onto their students and when they fail, they look for explanations in terms of students' ability, family background, motivation, or attitude.

- **Strategies for achieving objectives –** Teachers with a high sense of efficacy plan for student learning, set goals for themselves and their students and identify strategies to achieve them. Teachers with a low sense of efficacy tend to lack specific goals for their students. They are uncertain about what they would like their students to achieve and do not plan teaching strategies according to identifiable goals.

- **Positive affect –** Teachers with a high sense of efficacy feel good about teaching, about themselves and about their students. Those with low sense of efficacy are frustrated with teaching and frequently express discouragement and negative feelings about their work with students.

- **Senses of control –** Teachers with a high sense of efficacy are confident that they are able to influence student learning. Teachers with a low sense of efficacy experience a sense of futility in working with students.

- **Sense of common teacher-student goals –** Teachers with a high sense of efficacy feel that they are involved in a joint venture with students to achieve goals that they share in common. Those with a low sense of efficacy feel that they are engaged in a struggle with students whose goals and concerns are in opposition to theirs.

- **Democratic decision making** – Teachers with a high sense of efficacy involve students in decision-making about goals and strategies for achieving goals. Those with a low sense of efficacy impose their decisions regarding goals and learning strategies on students without involving them in the process of decision-making.

Ashton (1984) added two more differences between teachers with high efficacy and low efficacy. Their quantitative and qualitative observations of middle and high school teachers give support to the contention that a trusting relationship between teacher and student is a prerequisite for effective teaching and learning. They observed that high efficacy teachers maintained more positive accepting relationships with students. The same teachers possessed greater openness to student ideas and feelings, and were more likely to accept students' suggestions and initiations. The result was that those students became more enthusiastic and spontaneous in their classroom interactions.

2.7.3 SCIENCE TEACHER EFFICACY

Teacher Efficacy is a situation-specific and subject-specific construct (Bandura, 1986). A teacher can feel very confident in one subject like science but not the other such as language arts. And he/she can be very confident in teaching science but not in carrying out science experiments (situation-specific).

Teacher self-efficacy beliefs are valid predictors of practicing and prospective elementary teachers' behavior regarding Science teaching and learning (Riggs & Enochs, 1990). A number of researchers who had explored elementary teachers' Science subject matter knowledge found a direct relationship between Science knowledge and confidence in Science teaching ability or self-efficacy (for example, Schoon & Boone, 1998).

New teachers with strong Science content knowledge have higher self-efficacy about teaching science, but on the other hand, teachers who have taken the minimum required number of Science courses feel that their content knowledge is still lacking

(Cantrell, Young, & Moore, 2003, as cited in Pajares, 2006). As such, they tend to avoid teaching topics that they do not know well for fear that their students will ask questions that they cannot answer (Rice & Roychoudhury, 2003). Primary school teachers have been found to have generally low level of knowledge (Stevens & Wenner, 1996; Wenner, 1993), and this consequently contributed to their hesitancy, and possible inability to provide effective Science instruction in their classrooms.

2.7.4 SCIENCE TEACHER SELF-EFFICACY BELIEF & OUTCOME EXPECTANCY

Enochs and Riggs (1990) stated that a teacher's belief system is important in elementary science teaching. Based on Bandura's (1997) theory on construct of self-efficacy beliefs that personal self-efficacy is a judgment of one's ability to organize and execute given types of performances, while outcome expectancy is a judgment of the likely consequence such performances will produce, they suggest two types of beliefs that seemed relevant: belief that student learning can be influenced by effective teaching (outcome expectancy beliefs) and confidence or belief in one's own teaching ability (Gibson & Dembo, 1984).

Having one belief being high, for instance outcome expectancy, does not mean a strong belief with respect to the other measure. Riggs (1991) reported that elementary school teachers with low science teaching efficacy beliefs avoided science teaching even though their outcome expectancy beliefs regarding teaching generally were high.

2.7.5 STUDENT SELF-EFFICACY

Many researchers (e.g. Jinks & Morgan, 1999; Pajares & Schunk, 2001 and Zimmerman, Bandura, & Martinez-Pons, 1992, as cited in Webb-Williams, 2006) have found that both self-efficacy beliefs and academic achievement are positively correlated. Self-efficacy beliefs provide students with a sense of agency to motivate their learning through use of such self-regulatory processes as goal setting, self-monitoring, self-evaluating, and strategy use (Zimmerman, 2000).

Efficacious students were better at monitoring their working time, less likely to reject correct hypotheses prematurely and better at solving conceptual problems than inefficacious students of equal ability (Zimmerman, 2000).

Students' self-efficacy beliefs influence their academic performances in several ways. They influence the choices students make and the courses of action they pursue. If they are given a choice, students tend to engage in tasks about which they feel confident and avoid those in which they do not (Bandura & Schunk, 1981; Pajares, 2002). Likewise, Schunk (1981) found that the former also persisted longer and were more successful on difficult arithmetic tasks than children with low self-efficacy. Children with a stronger sense of self-efficacy solved more problems and chose to rework more problems than children of the same ability who maintained a low sense of self-efficacy (Collins, 1982, as cited in Bandura, 1997). Bandura (1997) believed that students may perform poorly either because they lack the skills or because they have the skills but lack the perceived personal efficacy to make optimal use of them.

Pajares (2002) stated that "Learning goals that are specific, short-term, and viewed as challenging but attainable enhance students' self-efficacy better than do goals that are general, long-term, or not viewed as attainable " (p. 15). Students believe that they can attain the former goals that offer clear standards against which to gauge progress. Students compare their progress against their goals as they work on tasks and apply the strategy. Schunk (1995) proposed that progress seen by the students strengthens self-efficacy and motivates students to continue to improve. Schunk (1995) added that another way to help the student succeed to raise self-efficacy is to provide students with a strategy. If the students believe they have the means for performing successfully, then they are apt to feel efficacious about doing so. They note their progress as they work on tasks and apply the strategy; this strengthens their self-efficacy. Verbalisation is another strategy that students can use to raise self-efficacy as they apply it especially in the early stages (Schunk, 1995). Such strategy directs students' attention to important task features, assists strategy encoding and retention, and helps them work systematically (Schunk, 1995).

2.7.6 WOMEN SELF-EFFICACY FOR TEACHING SCIENCE

Self-efficacy has gained scientific attention for explaining the exclusion of women from technological fields, particularly young women's lack of confidence in their own efficacy to handle technical situations adequately (Wender, 2004). When did women begin to develop low self-efficacy in science? Hackett and Betz (1981) suggested that women's socialization provides them with less exposure to the information that allows individuals to develop self-efficacy for traditionally male occupation.

Experiences frame our attitudes and beliefs and the values assigned to them by those around us impact our interpretations, as well as how we value our own experiences that make us who we are (Zapata, 2005). For example at home, parents often portray science as male domains (Meece & Courtney, 1992). Parents are more likely to buy scientific games for boys than for girls, and boys are more likely to play with toys that encourage manipulation or construction (Oakes, 1990).

The mothers in particular see Science as not suited to females and that has contributed to their daughters' negative attitudes toward Science (Otto, 1991). Self-efficacy beliefs also strongly influence female college students' choice of majors and career decisions. In some cases, unrealistically low self-efficacy perceptions not lack of capability or skill can be responsible for avoidance of academic courses and subsequent careers (Hackett, 1995).

Few studies have investigated gender differences in elementary teachers. One such study of teachers' attitudes toward Science and Science instruction was by Levin and Jones (1983) who reported that male elementary teachers had a significantly more positive attitude toward Science teaching. Those female teachers who ranked Science as a low instructional priority had the least positive attitude toward Science.

Riggs (1991) conducted a research on gender differences in elementary Science teacher self-efficacy. She reported higher scores for males on self-efficacy for science teaching in both the in-service and pre-service samples. There were no significant differences obtained for outcome expectancy scores. Riggs (1991) questioned the cause of this gender difference. Could this be explained by the female teachers' own lack of background in Science? She however offered a reason that the different experiences males and females can encounter within the same classroom. She quoted Sadker and Sadkers' (1986) report that both the quality and quantity of classroom interactions to be inequitable, with male students typically receiving more specific feedback from the teacher, and the trend seems to follow female students from elementary years through college.

Riggs (1991) also offered another proposal that the difference may also lie within the self-efficacy ratings of the male teachers, that the higher science self-efficacy ratings are due to the higher expectations put upon male teachers by those around them. The male teachers are often thrust into the role of Science coordinator for the school. This practice, as Riggs (1991) deemed, could have led to a self-fulfilling prophecy in that the male teachers and end up viewing themselves as science teaching experts.

By examining the background and experiences of woman leaders in primary science in South Australia who have developed the confidence and competence to teach science, Paige (1994) found that there were many inter-related factors that contributed to the their expertise in teaching primary science. Five factors stood out:

- influence and support from key people such as teachers, family, focus teachers, coordinators and university lecturers
- their own natural curiosity, personal interest, inquiring mind, and enjoyment of challenges and problem solving
- participation in long term, whole school training and development programs
- interest in and experience with the environment.
- the joy of children discovering and learning in science

2.7.7 SELF-EFFICACY OF MALE & FEMALE TEACHERS

There have been many studies comparing the self-efficacy of male and female teachers, many of which are conflicting. There were studies that found a statistically significant difference in pre-service teachers in favor of male teacher (Azar, 2010). Other studies found no statistically significant difference in the self-efficacy beliefs of the pre-service teachers according to gender (Arsal, 2006). Britner and Pajares

(2006) reported that there was a statistically significant difference in the self-efficacy perception of pre-service teachers according to gender.

On the comparison of teacher efficacy according to gender, Shahid and Thompson (2001) found that there was a positive relation between self-efficacy and gender and females have a higher level of teaching competency than that of males.

From all the results of the studies, it is observed that there is no clarity about whether the self-efficacy differs according to gender and the difference in the results of the studies may result from cultural differences (Azar, 2010).

2.8 INTERVENTIONS TO INCREASE SELF-EFFICACY

There are four principal sources of self-efficacy beliefs which are possible interventions to increase the self-efficacy of an individual. According to Bandura (1986), self-efficacy beliefs are developed in response to four sources of information: enactive mastery experiences that serve as indicators of capability; vicarious experiences that alter efficacy beliefs through transmission of competencies and comparison with the attainments of others, verbal persuasions and allied types of social influences that one possesses certain capabilities, and physiological / affective states from which people partly judge their capability, strength and vulnerability to dysfunction. In the following, Bandura's four principal sources of self-efficacy beliefs are elaborated upon.

2.8.1 ENACTIVE MASTERY EXPERIENCE

Bandura (1997) ranked enactive mastery experience as the first and most powerful influence on self-efficacy in which self-efficacy for a behaviour is increased by successfully performing the behavior (strongly related with regular physical activity). They provide the most authentic evidence of whether one can muster up whatever it takes to succeed.

On the other hand, the perception that one's performance has been a failure lowers efficacy beliefs, and that contributes to the expectation that future performances will also be inept. The level of arousal whether it is anxiety or excitement adds to the feeling of mastery or incompetence. Attributions also play a role, i.e. if a success is attributed to internal or controllable causes such as ability or effort, then self-efficacy is enhanced. However on the contrary, if one's success is attributed to luck or other people's intervention, then self-efficacy may not be strengthened (Bandura, 1993; Pintrich & Schunk, 1996).

Schoon and Boone (1998) offer other possible forms of mastery that Science content knowledge is one factor that has been linked with increased confidence and self-efficacy of primary teacher education students. Successes in mastering the understanding of Science subject matter could therefore be expected to enhance their feelings of efficacy for teaching Science. Such kind of mastery experience however is different from enactive mastery because it involves success in understanding something rather than success in doing something. This is referred to as 'cognitive content mastery' (Palmer, 2006).

2.8.1.1 PROFESSIONAL DEVELOPMENT & SELF-EFFICACY

Fullan (1991) offered a definition for Professional Development: "the sum total of formal and informal learning experiences throughout one's career from pre-service teacher education to retirement" (p. 326).

Professional development programmes have been successful in their ability to enhance teachers' feeling of self-efficacy. Effective professional development can have a long term effect on how teachers view their self-efficacy (Watson, 2006). Murphy et al. (2007) reported that professional development was found to be the most important factor influencing confidence primary science teaching. They added that confidence was significantly higher if teachers had carried out some professional development in primary Science, i.e. they were significantly more confident to teach subjects other than Science if they had carried out professional development in primary Science. After going through it, the teachers' confidence was significantly higher in developing children's scientific skills and understanding of Science concepts, and in their own Science teaching ability.

According to the Training and Development Agency for Schools (TDA) in the United Kingdom, Continuing Professional Development (CPD) consists of reflective activity designed to improve an individual's attributes, knowledge, understanding and skills. It supports individual needs and improves professional practice. According to the agency, there are possible sources of professional development. The first one is from other external expertise. This refers to external courses or further study or advice offered by local authorities, Further Education colleges, universities, subject associations and private providers.

The other source is through school networks (cross-school and virtual networks). Schools could conduct induction, coaching and mentoring, lesson observation and feedback, collaborative planning and teaching, shadowing, sharing good practice, whole school development events.

2.8.1.2 SCIENCE COURSES & SELF-EFFICACY

Certain studies have convincingly demonstrated that well-designed Science method courses can effectively induce positive changes in Science teaching self-efficacy (Palmer, 2006). Science education courses, especially those that concentrate on how to teach primary Science, have proven to raise the level of self-efficacy very successfully (Palmer, 2001).

He further reported that some of the course factors that could potentially increase the self-efficacy of the student teacher include the use of an inquiry approach (Posnanski, 2002), extensive use of hands-on activities (Butts, Koballa & Elliot, 1997), group investigations (van Zee et al., 2003), activities relevant to the primary classroom (Watters & Ginns, 2000), relating concepts to the real world (Kelly, 2000), practice teaching as a component of the methods course (Kelly, 2000), tutors modelling teaching techniques (Rice & Roychoudhury, 2003), and a classroom environment that emphasizes fun and success (Watters & Ginns, 2000).

2.8.2 VICARIOUS LEARNING

The second information is vicarious learning in which beliefs are often acquired through observation and interpretation, or hearing role models talk of their experiences. In observing the modeling behavior of others, the learner is able to reflect on past experiences with such behaviour and make meaning of its relevance in a new situation. Vicarious learning is particularly relevant when people have little previous experience in the task at hand (Palmer, 2006).

According to Bandura (1977), the degree to which the observer identifies with the model moderates the effect on the observer's self-efficacy. The more closely the observer identifies with the model, the stronger will be the impact on efficacy. When a model with whom the observer identifies performs well, the efficacy of the observer is enhanced. On the contrary, if the model performs poorly, the efficacy expectations of the observer decrease.

There are several modes of modeling influences: (1) effective actual modelling' occurs when one sees a person similar to oneself perform the task successfully; (2) 'symbolic modelling' occurs when individuals are exposed to effective models provided by television and other visual media; (3) 'self-modelling' occurs when individuals' performance are videotaped for them to watch, but only after the recordings have been edited to show only the favourable aspects; and (4) cognitive self-modelling' occurs when individuals visualize themselves performing successfully at the task (in Palmer 2006).

Zeldin and Pajares (2000) studied women who excelled at careers in areas of Mathematics Science, and Technology to better understand how their self-efficacy beliefs influenced their academic and career choices, and found that their vicarious experiences nourished their self-efficacy beliefs as they set out to meet the challenges required to succeed in male-dominated academic domains.

Thus parents and teachers should convey the right message to the girls for they develop higher self-efficacy beliefs in homes and classrooms in which parents and teachers stress the importance and value of academic skills, encourage girls to persevere in the face of academic and social barriers, and break down stereotypical conceptions regarding academic domains (Pajares, 2002). They have an important role to play for some of them may also discourage girls from pursuing scientific or technical occupations (Betz & Fitzgerald, 1987).

2.8.3 VERBAL PERSUASION

According to Bandura (1997), verbal persuasion is another means of strengthening people's beliefs that they possess the capabilities to achieve what they seek. Though verbal persuasion by peers and superiors has been found to be a weak source, it is important to teachers with little experience in a domain (Ross, 1995). Bandura (1997) elaborated that it is easier to sustain a sense of efficacy particularly when struggling with difficulties, if significant others express faith in one's capabilities than if they convey doubts.

Although verbal persuasion alone may have limitation in its power to create enduring increases in perceived efficacy, it can bolster self-change if the positive appraisal is within realistic bounds. If a person is persuaded verbally that he or she possess the capabilities to master given tasks, he or she is likely to mobilize greater effort and sustain it, than one who harbors self-doubts and dwell on personal deficiencies when difficulties arise. While persuasive boosts in perceived efficacy lead people to try hard enough to succeed, self-affirming beliefs promote development of skills and a sense of personal efficacy. It is stated that persuasory efficacy attributions have their greatest impact on people who have some reason to believe that they can produce effects through their actions (Chambliss & Murray, 1979a, 1979b). However Bandura warned against raising unrealistic beliefs of personal capabilities as they will not only invite failures that will discredit the persuaders, they will further undermine the recipients' beliefs in their capabilities.

2.8.3.1 MENTORSHIP

Mentorship is a very important process in raising the self-efficacy of Science teachers. Research has shown that mentoring has a positive impact on teacher efficacy (Ward, 2005; Laat & Watters, 1995). Through the process of mentoring, not only the mentees, but mentors would have something to gain from it. Reports have indicated that the mentors' self-efficacy grew stronger as they interacted with new teachers (Saffold, 2005).

The mentor's role is to prepare, negotiate and enable the mentee's teaching practices towards higher levels of teaching competencies (Zachary, 2002, as cited in Hudson, 2004). To assist the mentee to improve primary Science teaching practices, Hudson (2004) argues that mentors need to possess pedagogical knowledge of primary Science for guiding the mentee with planning, timetabling, preparation, implementation, classroom management strategies, teaching strategies, Science teaching knowledge, questioning skills, problem-solving strategies and assessment techniques. He added that expressing various viewpoints on teaching primary Science may also assist the mentee to formulate a pedagogical philosophy for teaching Science.

Problems may surface in mentoring relationships if there is a "lack of mentoring skills on the part of the mentor" (Soutter et al., 2000, p. 6, as cited in Hudson, 2004). Hudson (2004) cautioned about the role of the mentor: "A mentor's pedagogical knowledge of primary Science must be more advanced than a mentee's primary Science teaching knowledge if the mentor is to provide feedback that aims at progressing the mentee. The mentor should be able to articulate the primary Science teaching skills required of the mentee. If the mentor's pedagogical knowledge of primary Science teaching falls below a mentee's knowledge, then the mentor's credibility and suitability may come into question" (p. 216).

2.8.4 PHYSIOLOGICAL AND AFFECTIVE STATES

Physiological and Affective States are the fourth way that one is provided information about our efficacy beliefs. According to Bandura (1997), somatic indicators of personal efficacy are particularly relevant in health functioning and in coping. Lubkin and Larsen (2006) believed that high levels of arousal in stressful situations make us vulnerable to failure, and we will be more successful when we are not tense or agitated. They added that when the situation is uncontrollable, we inadvertently develop increased levels of distress that produce the very dysfunction we fear. Other physiological indicators also influence self-efficacy information; individual judge their fatigue, aches and pains, and even their mood states as indicators of their personal inefficacy. Bandura (1991) believed that altering beliefs related to physical status, stress levels, and correcting misinterpretations of bodily states is a major way of enhancing self-efficacy.

2.9 INSTRUMENTS FOR MEASURING TEACHER SELF-EFFICACY

Bandura's concept of social cognitive theory and his construct of self-efficacy contributed to several instruments to measure efficacy beliefs; they are: Teacher Efficacy Scale (Gibson & Dembo, 1984), Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990) and Ashton Vignettes (Ashton, Olejnik, Crocker & McAuliffe, 1982).

2.9.1 BANDURA'S TEACHER EFFICACY SCALE

Bandura (1977) maintained that self-efficacy is situation specific and cannot be identified in general terms (Welch, 1995).

With this in mind, Bandura (1997) proposed that a teachers' sense of efficacy is not necessarily homogeneous across the many different types of tasks teachers are asked to perform, nor across different subject matter. Hence, he constructed a 30-item instrument with seven subscales:

- Efficacy to influence decision making
- Efficacy to influence school resources
- Instructional efficacy
- Disciplinary efficacy
- Efficacy to enlist parental involvement
- Efficacy to enlist community involvement
- Efficacy to create a positive school climate.

Each item is measured on a 9-point scale anchored with the 5 notations: "nothing (1), very little (3), some influence (5), quite a bit (7), a great deal (9)." To explain the jump in numbers (example: 1 to 3, 3 to 5, 5 to 7, & 7 to 9), even numbers on the scale are intermediate numbers between two odd numbers.

This measure attempts to provide a multi-faceted picture of teachers' efficacy beliefs without becoming too narrow or specific. But, according to Woolfolk (2008), the reliability and validity information about the measure is unavailable. With this, such instrument is unsuitable for use in this study. Furthermore the proposed research needs an instrument that specifically measures science teaching efficacy beliefs.

Several scales were developed to measure self-efficacy (Hoy, 2008). Some examples of such scales are:

- The Teachers' Sense of efficacy Scale developed at OSU
- The Turkish Teachers' Sense of Efficacy Scale
- Bandura's Teacher Efficacy Scale
- Responsibility for Student Achievement
- Teacher Locus of Control
- The Webb Scale
- The Ashton Vignettes.

According to Hoy (2008), the abovementioned scales are unpopular - either because they never received wide acceptance or there were no published studies found in which other researchers who had adopted those scales.

2.9.2 GIBSON & DEMBO'S TEACHER EFFICACY SCALE

To measure teacher efficacy, Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES) to measure two constructs, namely PTE (9 items) and GTE (7 items) that are essentially uncorrelated subscales.

The instrument has been widely used and is "recognised as a standard measure of professional efficacy" (Ghaith & Yaghi, 1997, p. 453).

The scale has response options scored on a six-point Likert scale ranging from 1="strongly disagree" to 6 = "strongly agree". Use of the Gibson and Dembo (1984) Teacher Efficacy Scale allowed the three factors of teacher efficacy: teaching efficacy; personal efficacy; and, outcome efficacy to be examined. These three factors were considered in terms of the extent to which they explained the higher order instructional emphasis of teachers. Use of a three-factor or two-factor solution depended on factor analyses of the teacher efficacy scale and the extent to which the solution contributed to the central focus of the research on the relationship between teacher efficacy and higher order instructional emphasis.

The two factors of teaching efficacy and personal efficacy were to be used if it was found, as noted above with Woolfolk and Hoy (1990) that analysis using the three aspects of efficacy added nothing to analyses based on the two independent factors of teaching efficacy and personal efficacy.

In Henson et al.'s (2001) research on "A reliability generalization study of the teacher efficacy scale and related instruments", they stated that Ashton and Webb (1982) were the first to use the instrument and they argued that two items previously used by RAND researchers (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977) to study teacher efficacy corresponded to Bandura's self-efficacy and outcome expectancy dimensions of social cognitive theory.

These dimensions were known as personal teaching efficacy (PTE) and general teaching efficacy (GTE), respectively

2.9.3 SELF-EFFICACY BELIEFS ABOUT EQUITABLE SCIENCE TEACHING

Modeled after Riggs (1988) and Riggs and Enochs' (1990) STEBI and STEBI-B instruments respectively, Ritter (1999) developed, validated and established the reliability of an instrument known as '*Self-Efficacy Beliefs about Equitable Science* Teaching (SEBEST)' to assess the self-efficacy beliefs of prospective elementary teachers (pre-service) with regards to Science teaching and learning for diverse learners.

She claimed that based on the standardised development procedures used and the associated evidence, the SEBEST appears to be content and construct valid instrument, with high internal reliability and moderate test-retest reliability qualities, for use with prospective elementary teachers to assess self-efficacy beliefs for teaching and learning science for diverse learners. However this instrument with its moderate test-retest reliability qualities may not be suitable for the proposed study. Moreover, the availability of a form of the SEBEST for practicing primary teachers is not present.

2.9.4 SCIENCE TEACHING BELIEFS INSTRUMENT – A (STEBI – A)

Bandura (1981) stressed that self-efficacy is highly context dependent – one may have a high self-efficacy with respect to one task but a low self-efficacy with respect to another. If we were to apply this in education, a teacher's overall level of self-efficacy may not accurately mirror the teacher's beliefs about his/her ability to implement effective programmes in specific subjects such as Science. With Bandura (1986) theory of subject-specific construct and following the work of Gibson and Dembo (1984) in mind, Riggs and Enochs (1990) developed a specific instrument called the Science Teaching Efficacy Belief Instrument (STEBI) to measure efficacy of teaching science for in-service teacher.

2.9.4.1 PERSONAL SCIENCE TEACHING EFFICACY & SCIENCE TEACHING OUTCOME EXPECTANCY

Based on the Teacher Efficacy Scale, the STEBI is composed of two subscales known as the Personal Science Teaching Efficacy (PSTE) and the Science Teaching Outcome Expectancy (STOE). There are 25 questions on the STEBI form; the PSTE consisted of 13 items while the STOE consisted of 12 items. All the items are placed randomly in the list of questions so that a participant is unaware which of the two subscales is being measured. The two scales are uncorrelated, i.e. they are different and separate constructs. Hence, the data of the STEBI are generated, analysed and interpreted separately. This is because the Science Teaching Efficacy (PSTE) deals with a teacher's own belief if he/she has the ability to teach science, while the Science Teaching Outcome Expectancy (STOE) refers to a teacher's belief in his/her ability to influence students' science learning by given effective instruction. Below are the questions used to measure a teacher's PSTE or STOE. Every of the 13 questions on the PSTE has the pronoun "I" indicating that they are asking the teachers what they feel about their own personal teaching efficacy. On the other hand, questions in the STOE are usually general statements, and each either has the word "teacher" or "teaching" in it.

Questionnaires for the PSTE and STOE are listed as follows:

2.9.4.2 PERSONAL SCIENCE TEACHING EFFICACY

- I am continually finding better ways to teach Science.
- Even if I try very hard, I do not teach Science as well as I do most subjects.
- I know the steps necessary to teach Science concepts effectively.
- I am not very effective in monitoring Science experiments.
- I will generally teach Science ineffectively.
- I understand Science concepts well enough to be effective in teaching elementary science.
- I find it difficult to explain to students why Science experiments work.
- I am typically able to answer students' Science questions.
- I wonder if I have the necessary skills to teach Science.
- Given a choice, I would not invite the Principal to evaluate my Science teaching.
- When a student has difficulty understanding a Science concept, I will usually be at a loss as to how to help the student understand it better.
- When teaching Science, I will usually welcome student questions.
- I do not know what to do to turn students on to Science.

2.9.4.3 SCIENCE TEACHING OUTCOME EXPECTANCY

- When a student does better than usual in Science, it is often because the teacher exerted a little extra effort.
- When the Science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
- If students are underachieving in science, it is most likely due to ineffective Science teaching.
- The inadequacy of a student's Science background can be overcome by good teaching.

- The low Science achievement of some students cannot generally be blamed on their teachers.
- When a low-achieving child progresses in Science, it is usually due to extra attention given by the teacher
- Increased effort in Science teaching produces little change in some students' Science achievement.
- The teacher is generally responsible for the achievement of students in Science.
- Students' achievement in Science is directly related to their teacher's effectiveness in Science teaching.
- If parents comment that their child is showing more interest in Science at school, it is probably due to the performance of the child's teacher.
- Effectiveness in Science teaching has little influence on the achievement of students with low motivation.
- Even teachers with good Science teaching abilities cannot help some kids learn Science.

2.9.4.4 STUDIES USING STEBI - A

- The value of the STEBI-A has been established, for example, by Ramey-Gassert (1994), who in a study of experienced teachers in the United States identified a range of factors that contributed to high science teaching self-efficacy beliefs. These included recollections of positive, enjoyable Science-related antecedent experiences from which they developed a lasting interest in Science, a positive desire both to help their students and to improve their Science teaching. High outcome expectancy was related to having personally experienced success in Science and with teaching Science. In particular, high STOE teachers saw external variables as challenges to be overcome and not insurmountable. Similar characteristics were also reported by Riggs (1995).

- Riggs and Enoch (1990) said that teacher belief systems had been neglected as a possible contributor to behaviour patterns that affect science teaching. Hence they conducted a pilot and a major study which the combined Personal Science Teaching Efficacy Belief scale and the Science Teaching Outcome Expectancy scale instrument. Factor analysis supported the contention that the scales are distinct and measurable constructs. Through the above updated version of factor analysis, they reported that the instrument was stable and valid. Both concluded that the STEBI could serve as "Tools for studying elementary teachers' efficacy beliefs" (Riggs and Enoch, 1990, p. 633). Many researchers have adopted Riggs (1988), and Enochs and Riggs (1990) methods to measure Science self-efficacy of teachers. For example, Kiviet and Andile's (2003) used the STEBI to research on sex differences in self-efficacy beliefs of elementary Science teachers. Schriver & Czerniak (1999) examined differences in the science teachers' self-efficacy and outcome expectancy, perceptions of support, and knowledge of developmental appropriate curriculum and instruction in junior high and middle schools. Roberts, Henson, Tharp and Moreno (2001) tried to provide a framework for understanding the optimum length of teacher in-service activities when increasing teacher efficacy is a goal of an intervention.

2.9.4.5 SCIENCE TEACHING BELIEFS INSTRUMENT – B (STEBI - B)

Enochs and Riggs (1990) subsequently developed and validated another instrument entitled, '*Science Teaching Efficacy Beliefs Instrument (STEBI-B)'*, for prospective science teachers. According to Ritter (1999), both the instruments, STEBI – A and STEBI – B, have become widely used in science education to inform teacher educators about the science beliefs of teachers.

She added that the instruments have been re-written in other languages because the importance of Science self-efficacy beliefs is recognised in other countries as a critical role in teaching effectively.

2.10 CHAPTER SUMMARY

In this chapter, I have listed the definitions of self-efficacy of different researchers. This is followed by a comparison of the different constructs of self-efficacy, self-confidence, self-esteem, self-concept, perceived control and locus of control. I also stated the educational implications of self-efficacy and defined teacher-efficacy with a description of teachers with high and low levels of efficacy.

I explained about Science teacher efficacy, student efficacy and women self-efficacy. Lastly, Bandura's (1997) suggestions that increase the self-efficacy of an individual and the advantages of professional development, science course and mentorship in enhancing self-efficacy are discussed.

I would like to caution that the reports and literature review in chapters 1 and 2 had been drawn primarily on studies from North America, Europe, Australia and several other countries. Most of the studies were not carried out in the context of Singapore or in East Asia which my research is based upon.

It should be kept in mind that there is important class, racial and cultural differences across these samples - even within a country - that are likely to affect the nature and extent of gender differences observed. For example, the strength of the relationships between gender, interest in areas of study, and academic achievement varies across countries (Evans, Schweingruber & Stevenson, 2002), and race may be as important as, or even more important than, gender in determining success in science areas (Hanson, 2004).

The methods for this research, which is to measure the science self-efficacy of the Singapore primary school female teachers and identify the barriers and enablers they face, comprised of the STEBI-A, a survey and four semi-structured interviews. The research methodology will be presented in the next chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The sources of data for this study were primarily drawn from quantitative and qualitative (Mixed Method Designs). Before collecting any data, a literature review was conducted to extend the researcher's knowledge and understanding of the different philosophical, epistemological and ontological positions held by qualitative and quantitative approaches to research and the contradictions which may arise by combining these approaches. Following that, the strengths and weaknesses of the different research traditions, approaches and strategies, and the different ways in which methods can be mixed are discussed. Then explanation of how these apparently contradictory approaches were successfully combined in this study and the research procedure for this thesis is given.

3.2 QUALITATIVE & QUALITATIVE RESEARCH

3.2.1 RESEARCH EPISTEMOLOGY & ONTOLOGY

According to Ruddock (2007), epistemology and ontology are important in that they illustrate how research begins by outlining theoretical suppositions that are taken as given by the researcher. Grix (2002) wrote that all research begins with ontology, after which one's epistemological and methodological positions logically follow. Ontological claims are "claims and assumptions that are made about the nature of social reality, claims about what exists, what it looks like, what units make it up and how these units interact with each other. In short, ontological assumptions are concerned with what we believe constitutes social reality" (Blaikie, 2000, p.8). Blaikie (2000) describes epistemology as "the possible ways of gaining knowledge of social reality, whatever it is understood to be. In short, claims about how what is assumed to exist can be known" (p.8).

3.2.1.1 QUALITATIVE RESEARCH

Qualitative research according to Creswell (2008) is a type of educational research in which the researcher relies on the views of participants; ask broad, general questions; collects data consisting largely of words from participants; describes and analyzes these words for themes; and conducts the inquiry in a subjective, biased manner. In such research, data analysis tends to consist of text analysis, and involves developing a description and themes.

The results of qualitative Research are less generalizable. It is considered as more subjective, suggesting and describing a situation from the point of view of those who experienced it. It is considered as more in-depth in information. The validity and reliability are largely dependable on the researcher's skill and rigor. Statistical tests are not available for analysis. It follows an unstructured or semi-structured responses options, and focused on inductive process to formulate theory or hypotheses.

3.2.1.2 QUANTITATIVE RESEARCH

Quantitative research is another type of educational research in which the researcher decides what to study; asks specific, narrow questions; collects quantifiable data from participants; analyzes these numbers using statistics; and conducts the inquiry in an unbiased, objective manner. Data analysis in quantitative research tends to consist of statistical analysis, and involves describing trends, comparing group differences, or relating variables. The interpretation tends to consist of comparing results with prior predictions and past research (Creswell, 2008).

The results of quantitative research are more generalizable. It is more objective and provides observed effects of a programme on a problem or condition. Though it is less in-depth, it gives more breadth of information across a large number of cases. The reliability and validity are dependent on the measurement device or instrument the researcher used. With it, statistical tests are used for analysis. It has fixed response options, and focused on deductive process to test pre-specified concepts, constructs, and hypothesis that make up a theory.

3.3 MIXED METHODS RESEARCH DESIGN

According to Creswell and Plano Clark (2007), a mixed methods research design is defined as a procedure for collecting, analyzing and "mixing" both quantitative and qualitative research and methods in a single study to understand a research problem. Creswell (2008) stated that "the basic assumption is that the use of both quantitative and qualitative methods, in combination, provides a better understanding of the research problem and questions than either method by itself". (p. 552). He further advised that mixed methods research is not simply collecting two distinct "strands" of research – qualitative and quantitative, but it consists of merging, integrating, linking, or embedding the "strands."

In the social sciences, mixed methods research has become increasingly popular and may be considered a legitimate, stand-alone research (Tashakkori & Teddlie, 2003). When both quantitative and qualitative data are included in a study, researchers may enrich their results in ways that one form of data does not allow (Tashakkori & Teddlie, 1998). Using both quantitative and qualitative data allows researchers to simultaneously generalize results from a sample to a population and to gain a deeper understanding of the phenomenon of interest. It also allows researchers to test theoretical models and to modify them based on participant feedback (Hanson, Creswell, Clark, Petska, & Creswell, 2005).

Johnson and Christensen (2004) pointed out the weaknesses of Mixed Methods Designs. Firstly, it can be difficult for one researcher to carry out both qualitative and quantitative research especially if two or more approaches are to be done simultaneously. Because the design involves two or more methods, the researcher will have to learn about multiple methods and approaches and understand how to appropriately mix them. Hence it is more expensive and time-consuming. Methodological purists are against this design and contend that a researcher should always work within either a qualitative or a quantitative paradigm. Details of mixed research remain to be fully worked out by research methodologists.

3.3.1 MIXED METHODS – THE THREE PRIMARY DESIGNS

In the Mixed Methods approach, there are three primary designs: the Triangulation Design, the Explanatory Design, and the Exploratory Design (Creswell & Plano Clark, 2007). In the next few sections, the three different designs will be explained according to the definitions made by Creswell (2008).

3.3.1.1 TRIANGULATION DESIGN

The aim of triangulation design is to collect both quantitative and qualitative data simultaneously, merge the data, and use the results to understand a research problem. A basic rationale for this design is that one data-collection form supplies strengths to offset the weaknesses of other form, i.e. quantitative scores on an instrument from many individuals provide strengths to offset the weaknesses of qualitative documents from a few people. Also, qualitative, in depth observation of a few people offers strength to quantitative data that does not adequately provide detailed information about the context in which individuals provide information. For such study, both quantitative and qualitative data are gathered and analysed separately. The analysis of both datasets are then compared, and from there, interpretation as to if the results support or contradict each other is made.

Through Triangulation Design, the researcher can combine the advantages of each form of data – quantitative data provide for generalizability and qualitative data provide information about the context or setting. What the researcher gathers are the best features of both quantitative and qualitative data collection. The disadvantages of this design are that it is labour intensive and it is difficult to transform one form of data into other form to integrate and compare databases. Inconsistent results may emerge if integration is possible, making it necessary to collect additional data or revisit the collected databases to reconcile the difference.

3.3.1.1.1 EMBEDDED DESIGN

The Embedded Design is similar to the triangulation design. It is to collect quantitative and qualitative data simultaneously but to have one form of data play a supportive role to the other form of data. The second form of data will augment or support the primary form of data. The strong point of such design is that it combines the advantages of both quantitative and qualitative data; it provides a type of mixed methods design in which the researcher can collect qualitative data, but the overall design still emphasizes quantitative approaches. The disadvantages of this design are: it is labour intensive for a single researcher to collect both quantitative and qualitative data, and that the two databases may not be easily compared because the data address different research questions. There is a probability that the introduction of qualitative data collection during an experiment will influence the outcomes. The researcher needs to have strategies to minimize this effect.

3.3.1.2 THE EXPLANATORY DESIGN

Creswell (2008) considers Explanatory mixed methods design as probably the most popular form of mixed methods design in educational research. An explanatory mixed methods design consists of first collecting quantitative results and then collecting qualitative data to help explain or elaborate on the quantitative results. Such an approach is used because the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture.

The advantages of this design are that the researcher does not need to converge or integrate two different forms of data for the quantitative and qualitative parts are clearly identified. Such a design captures the best of both quantitative and qualitative data. The drawbacks of this design are that it is labour intensive, and it requires expertise and time to collect both quantitative and qualitative data. In addition, the researcher needs to determine what aspect of the quantitative results to use in the follow-up.

3.3.1.2.1 ANALYTIC & INTERPRETIVE PROCEDURES

Creswell (2008) cited four examples of analytic and interpretive procedures for Explanatory Design. The first analytic procedure is to follow up on outliers or extreme cases. This is done through gathering quantitative data and identifying outlier or residual cases. This is followed by collecting of qualitative data to explore the characteristics of these cases (Caracelli & Greene, 1993). The second analytical procedure is explaining results by conducting a quantitative survey to identify how two or more groups compare on a variable. This is then followed up with qualitative interviews to explore the reasons why these differences were found. The next example is using a typology. This is done by conducting a quantitative survey and developing factors through a factor analysis. These factors are used as typology to identify themes in qualitative data, such as observations or interviews (Caracelli & Greene, 1993). The final one is examining multi-levels which is to conduct a survey at the student level. Then gather qualitative data through interviews at the class level. A survey is done with the entire school at the school level. This is followed by the collection of qualitative data at the district level. The information from each level is built to the next level (Tashakkori & Teddlie. 1998).

3.3.1.3 THE EXPLORATORY DESIGN

In the Exploratory Design, the researcher will begin with qualitative data and then collects quantitative information. This is done so as to explore a phenomenon, and then collecting the quantitative data to explain relationships found in the qualitative data. One of the applications of this design is to explore a phenomenon, identify themes, design an instrument, and then test it. It is used when researchers find that existing instruments, variables, and measures may not be known or available for the population under study. The advantage of Exploratory Design is it allows the researcher to identify measures actually grounded in the data obtained from study participants. He can initially explore views by listening to participants rather than approach a topic with a predetermined set of variables. The downside is it is time-consuming as it requires extensive data collection due to the testing of an instrument. The researcher also needs to make decisions about the most appropriate themes to measure in the follow-up, quantitative phase of the study.

3.4 RATIONALE FOR ADOPTING MIXED METHODS APPRROACH

Both qualitative and quantitative research methods have their own merits. Through questionnaires, a researcher can gather evidence of patterns amongst large populations, but qualitative interview data frequently gather more in-depth insights on participant attitudes, thoughts, and actions (Kendall, 2008). Though there are contradictions between the two (as explained on Page 62), the objective is to combine the two traditions so as to get the best and advantages of each one of them. Hence the Mixed Methods approach cum Explanatory Design (following up on outliers or extreme cases) was adopted for this study because: 1) quantitative data are required to compare the Science self-efficacy of female and male primary Science teachers so as to provide generalization of which gender has a higher Science self-efficacy; 2) from the quantitative data (STEBI-A), four outlier cases could be selected for the interview so as to gain a deeper understanding of the enablers and obstacles female teachers faced that affected their Science self-efficacy.

3.5 RATIONALE FOR ANALYSING QUALITATIVE DATA SEPARATELY

Based on the Explanatory Design approach (collecting quantitative results followed by qualitative data to help explain or elaborate on the quantitative results) of Mixed Methods, the qualitative data are analysed separately as it helps to explain and elaborate on the factors affecting the self-efficacy of Science teachers. This approach allows the gathering of more in-depth insights on teacher participant attitudes, thoughts, and actions of their science teaching experience.

3.6 DATA ANALYSIS - CODING OF THEMES / CATEGORIES

Taylor-Powell and Renner (2003) reported that analysing qualitative data is both time-consuming and laborious. Bearing this in mind, utmost caution and patience were exercised during the analysis of the data in this research. The most important point was not to impose any preconceived ideas into the process.

To fully understand the data, the four transcripts were read and re-read, and impression of them was written along the way. The data were organised by question to look across all respondents and their answers in order to identify consistencies and differences. This was followed by identifying themes. Based on Taylor-Powell and Renner's advice, abbreviated codes of a few letters were assigned to be placed next to the themes so as to help organise the data into categories. In the initiate stage of coding, dozens of themes were gathered, which were subsequently re-grouped, some of them of similar nature together so as to cut down on the large quantity of data. In this way, the data would be clearer and more manageable. Building of categories continued until no new themes or subcategories were identified. From the data, hand tabulations were used to search and count the frequency a theme or how often one theme occurs with another. The results are presented in graphs.

According to Taylor-Powell and Renner (2003), "It is often helpful to include quotes or descriptive examples to illustrate your points and bring the data to life" (p. 5). Quotes from the four interviews that best represented the investigation or exemplify a point are presented. To substantiate those points, the interviewees were asked to confirm what had been quoted from the interview was really what they meant during the post-interviews with them.

3.7 SOUNDNESS OF QUALITATIVE RESEARCH – FOUR CRITERIA

Guba and Lincoln (2003) proposed four criteria, i.e. credibility (internal validity), transferability (external validity), dependability (reliability) and confirmability (objectivity) for judging the soundness of qualitative research and offered different standards for judging the quality of research as an alternative to more traditional quantitatively-oriented criteria. They believed that the four criteria better reflected the underlying assumptions involved in much qualitative research:

Credibility – this involves establishing the results of qualitative research are credible or believable judging from the point view of the participants in the research. Because the purpose of qualitative research is to describe or understand the phenomena of interest from the participant's eyes, they are the only ones who can legitimately judge the credibility of the results.

Transferability – this refers to the degree that the results of qualitative research can be generalised (job of the generalizer) or transferred to other contexts or settings. The transferability can be enhanced if one does a thorough job of describing the research context and assumptions that were central to the research. It is the responsibility of the one who transfer the results to a different context is their responsible for making the judgment of how sensible the transfer is.

Dependability – it emphasises the need for the researcher to account for the ever-changing context within which research occurs. The research is responsible for describing the changes that occur in the setting and how these changes affected the way the research approached the study.

Confirmability – it is the degree to which the results could be confirmed or corroborated by others. To enhance confirmability, one can document the procedures for checking and re-checking the data throughout the study. The results can also be confirmed by another researcher, and it can be documented. The issue is if the logic and interpretive nature can be made transparent to others. The reader can agree with or confirm the interpretation made and conclusions drawn. The final confirmation is through examining the data collection and analysis procedures and makes judgments about the potential for bias or distortion.

For credibility of the results, the four interviewees read the transcripts and drafts of the thesis to ensure that what had been interpreted of the transcripts was truly what they meant. To fulfill the criterion of confirmability, the four tapes of the interviews and transcripts were reviewed for checking and re-checking. Again, objectivity was kept in mind at all times to avoid any potentiality for bias.

3.8 RESEARCH PROCEDURE

A set of forms was sent to teachers (through random sampling) comprising of a cover letter, a STEBI-A form and a survey form. In this survey form, the teachers were requested to write down their answers to the questions pertaining to their Science-related experiences. The STEBI-A was used to compare the self-efficacy (PSTE and STOE) level of both the male and female teachers. From the scores of the STEBI-A PSTE subscale, four outliers (two highest scoring and two lowest scoring female teachers) were identified for the interviews.

3.8.1 COVER LETTER TO TEACHER PARTICIPANTS

To begin the process of data collection, a cover letter (Appendix 1) together with the forms stating the purpose of the study was sent to all the selected teacher participants. To encourage them to take part in this survey the letter stated the incentive and, most importantly, assured them that their details would be kept strictly confidential. They were free to put a fictitious name if they wished. The letter also emphasised that their participation and contribution were very important to this research.

On the second page, a form requesting the teacher participants' particulars was attached. Below the demographic questionnaire, they were requested to write:

- Their years of teaching in primary school
- Their current level(s) that they are teaching
- Their position in school
- The subject(s) they taught before
- Their current responsibility pertaining to Science
- Their years of teaching Science
- Their highest education level
- Science content courses or subjects that they had taken.

§ 3.8.2 SCIENCE TEACHING BELIEFS INSTRUMENT – A (STEBI – A)

The only instrument used was the Science Teaching Beliefs Instrument – A, with the 25-item Likert scale developed by Riggs and Enochs (1990) to measure primary school teachers' personal Science teaching efficacy beliefs and Science teaching outcome expectancy.

Used by many researchers to measure Science teaching efficacy beliefs, the STEBI has been proven to be a valid and reliable tool. Riggs and Enochs (1990) reported that the items in the self-efficacy scale and outcome expectancy scale had high internal reliability (0.89, 0.76). This instrument uses a 5-choice 25-item Likert-type scale (1=strongly disagree, 2=disagree, 3=not sure, 4=agree, and 5=strongly agree). STEBI-A has two scales: Personal Science Teaching Self-efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE).

To calculate the individual score, individual scores on each of the scales were added up, remembering to reverse score the negative ones. For instance PSTE questions are 2+3+5+6+8+12+18+19+21+22+24 (the score for Questions 3, 6, 8 ,17, 19, 21, 22, 24 were reversed, i.e. Strongly Agree is a 1 whereas for the positive questions Strongly Agree is a 5). With this instrument, the Science self-efficacy of the female teachers was compared with their male counterpart.

An email was sent to Dr. Iris Riggs, the developer of the STEBI, to seek permission for the use of the instrument in my research. Dr. Riggs was very kind to grant the permission.

The name of the instrument STEBI however had to be changed. Laat and Watters (1995) had raised their concern over the name '*Science Teaching Beliefs Instrument'* for their survey, commenting that it was unfriendly. As such they changed it to 'Science Teaching Survey' to avoid any perceptions of a challenge to the teachers' professionalism. With the same concern as them, and to prevent any potential misperception on the part of the participants, the '*Science Teaching Beliefs Instrument'* was renamed to the '*Primary Science Teaching Survey (PSTS)'* in this research.

This name, especially the word 'survey', is understood by most people and this meant that it would be seen as a survey to learn about their experience as a Science teacher rather than an instrument to measure a certain vague item that could possibly confuse the teacher participants. Moreover, Bandura (2006) also advised using a nondescript title instead of 'Self-Efficacy'.

The names of the two designers and its original name are printed below the survey form to acknowledge their valuable contribution to this survey form. Throughout the whole thesis, STEBI-A is used instead of PSTS to avoid confusion.

Two small modifications were made to the wordings in the STEBI-A form. The word 'elementary' in the form (Question 12) was changed to 'primary' Science so as to fit the local context – everyone in Singapore will immediately recognise 'primary' but not 'elementary'. In addition, the acronym 'HOD' (Head of Department) in brackets was added after 'Principal' for Question 21, as most lessons in local schools are observed or evaluated by an HOD.

§ 3.8.3 SURVEY

Owens (2002) explained the reasons for doing a survey. The uniqueness lies with the fact we are able to gather information not available from other sources. Probability Sampling is unbiased representation of population of interest. We are able to achieve standardization of measurement as the same information is collected from every respondent. In the analysis, the survey data can also complement existing data from secondary source.

Owens (2002) also listed out the advantages of mail survey: it is generally the most economical; it can be administered by smaller team of people (no field staff); it can accessed to otherwise difficult to locate, busy populations; respondents can look up information or consult with others.
However, mail survey also has disadvantages according to him: it is the most difficult way to obtain cooperation; there is no interviewer involved in collection of data; a good sample is needed; incentive for respondents is more likely to be needed, and the data collection period is general long.

3.8.4 QUESTIONS ON THE SURVEY FORM

The survey consisted of 10 open-ended review questions (see below). This questionnaire was filled out alongside the STEBI-A that the teachers received.

In addition, the questions probed teachers' beliefs about their Science teaching experience as not all the teachers could be interviewed.

Through their responses to the following questions, a better understanding of their Science-related antecedents and experiences would be gained, and enablers and obstacles that were/are affecting optimisation of Science education in Singapore primary schools could be identified:

- Do you have the necessary adequate training/education to teach Science?
- Did you receive anything (praise, feedback, etc) from anyone that made believe you could teach Science well?

- How did / does the Science Department help you to raise your Science-teaching efficacy?
- Which is the subject that you consult your colleagues about most frequently?
- What are the major obstacles you face that stand in your way to optimum Science teaching?
- Do Singapore female Primary teachers believe they can teach Science as well as their male counterpart, if not better?
- Who (if anybody) do you model themselves on as a Science teacher and why?
- What did / will you do when you encounter trouble or problem in teaching Science?
- Which subject, English, Mathematics or Science, is the female teachers' most confident subject to teach?
- Which subject, English, Mathematics or Science, is the female teachers' least confident subject to teach?

§ 3.8.5 FOUR SEMI-STRUCTURED INTERVIEWS

The use of interviewing as a method for educational research is now agreed upon as a key method of data collection (Berry, 1999). Interviews are conversations (Kvale, 1996) and they are attempts to understand the world from the subjects' point of view, to unfold the meaning of peoples' experiences, to uncover their lived world prior to Scientific explanations. The structured or semi-structured interview is more flexible as it allows the interviewer to probe further or ask follow-up questions based on the response of the interviewee.

The two-way dialogue or a conversation with the participants would give the researcher a greater chance of getting in touch with the participants 'inner world of experience' (Kok, 2008, p. 41). The interview attempted to explore the female teachers' personal reflections on their family background, their own schooling (in primary, secondary, polytechnics or junior college and university) experiences, tacit or prior knowledge and other contextual issues pertaining to Science.

Besides that, their perceptions of the National Institute of Education, their current school and Science classroom contextual factors that had an impact on their teaching, were probed. Evidence of effort and perseverance and documented the teachers' perceptions of intrinsic and extrinsic enablers and barriers to teaching Science were also sought.

Kvale (1996) suggested for seven stages in designing and implementing an interview study, which are summarised as follows:

§ **Thematizing** - Before thinking about particular methods or interview formats, one needs to be clear on the purpose of the study and the topic to be investigated. The questions of "why" and "what" need to be answered before the question of "how" can be answered. This is as important in a qualitative evaluation study as in a quantitative one.

§ **Designing** - The overall design for the study, including the later stages of analysing and reporting, should be planned before the interviewing begins.

§ **Interviewing** - The interviewer is the instrument in this type of evaluation (Guba & Lincoln, 1981, as cited in Patton, 1987). The "instrument" can be affected by factors like fatigue, personality, and knowledge, as well as levels of skill, training, and experience. Face-to-face interview is also an observation and the skilled interviewer is sensitive to nonverbal messages, effects of the setting on the interview, and nuances of the relationship (Patton, 1987). While these subjective factors are sometimes considered threats to validity, skilled interviewer can use flexibility and insight to ensure an in-depth, detailed understanding of the participant's experience.

§ **Transcribing** - Both Kvale (1996) and Patton (1990) provide detailed practical suggestions for this process, ranging from ensuring that your tape recorder has good batteries to developing a sensitivity to the linguistic differences between oral speech and written text.

§ **Analyzing** - Data analysis is an issue that should be considered very early in the process of designing a study. Qualitative interviews and their transcripts produce a large volume of material which must be condensed, categorized or otherwise interpreted and made meaningful, and this may turn out to be one of the most costly and time-consuming aspects of the evaluation. If time and resources are limited, a more standardized interview formats which are easier to code and interpret could be used.

§ **Verifying** - In traditional research terms, this means determining reliability (how consistent the findings are), validity (whether the study really investigates what you intended to investigate), and generalisability (whether the findings apply to anyone outside of this particular program). In qualitative studies, one important way of verifying findings or establishing validity is to actually take transcripts or analyzed results back to some of the interview participants, and ask them if this is really what they meant.

§ **Reporting** - If the evaluation report is to effectively communicate findings, it must a) be in a form that meets some accepted scientific criteria, b) meet ethical standards such as confidentiality and respect, and c) be readable and usable for its intended audiences.

3.8.6 PILOT STUDY

Walliman (2005) suggested performing a pilot study (also known as pilot experiment) in which a questionnaire would be pre-tested on a small number of people of a type similar to that of the intended sample. This is to anticipate any problems of comprehension or other sources of confusion. For this study per se, three teachers - two males and a female - were chosen to scrutinise the questionnaire forms and attend a semi-structured interview before the actual research was carried out with the remaining participants.

3.8.6.1 MS JIN'S COMMENT

The first teacher in the pilot study was a female colleague, Ms. Jin, a primary school teacher. She perused the first draft of the survey form and then went through each and every question to ascertain if her interpretation of the questions was correct. She commented that some of the questions in the first draft were rather vague, difficult to comprehend or outright intrusive. As a participant, it was important for her to fill out a survey form comfortably and quickly, but she took some time to comprehend the following questions. 'What do you think the major issues are that stand in the way to optimum science teaching?' Although she finally understood it after reading it for the second time and after having queried if her interpretation was correct, she found the question could be simplified into: 'What are the major obstacles you face that prevent you from optimising Science teaching?' She also suggested changing the question 'Which subject would you prefer not to teach - English, Mathematics or Science?' to 'Which is your least preferred subject to teach?' as it "sounds less intrusive".

One of the most vital points that Ms. Jin made was there were too many open-ended questions in the survey form. This would inevitably lengthen the time the participants had to take to fill out the survey forms, which could discourage many from completing them. She also deemed two or three open-ended questions as being "too invasive".

She reminded that most teacher participants who did not know the researcher personally would probably be reluctant to provide their inner thoughts on teaching to a complete stranger. With that consideration, open-ended questions were reduced and questions reserved for the interview. In that way, the interviewee could choose if they wanted to answer any question which they were uncomfortable with, for building a good rapport with them was crucial to elicit more information from them about their Science teaching. Although questions in the STEBI – A form are all standardised and cannot be changed or modified drastically, Ms. Jin suggested re-designing the layout of the form to make it more user-friendly, fun and appealing to fill out (see annex A). She also suggested changing the word "elementary" (used in United States of America) to "primary" to suit the local context.

After scrutinizing the questionnaire, Ms. Jin popped a question: "What makes you think that the teachers will be willing to complete the long survey for a complete stranger and then take the time to walk to the postbox to mail the forms back to you? How many letters are you posting to the teachers? How many respondents are you hoping for? I personally would never do that! (take the time to fill out the forms and walk to the postbox to mail it)".

This became the main concern for this thesis but a trip to a local shop offered an idea. The Colgate toothpaste company was promoting a new toothpaste for sensitive teeth and the consumer could try it by first buying a tube for $10. Using the receipt and a form, the consumer could then mail them back to the company to get a refund of the $10. At that moment no plans were made for any purchase at the shop, but learning about the little 'incentive', i.e. a free tube of toothpaste, the researcher went for it. Upon reaching home, the form was filled out and posted back to the company. If a $10 refund could make a very busy man (like me) walk to the postbox, then a $10 voucher for any returned form for my survey should encourage many teachers to participate in this survey. As for the interviewees, to compensate them for their time, they would be paid $50 each.

When Ms. Jin was informed about the monetary incentive of $10 for returning the survey forms and $50 for the interviewee, she was certain that the response would be promising. She, for sure, "will try to fill out the form… and attend the interview if got the time."

3.8.6.2 MR. KENNETH'S COMMENT

The second draft of the survey forms (after Ms. Jin's comment) was emailed to Mr. Kenneth. His answers were brief. He found the questions straightforward and non-intrusive. Minimal editing was done to the second draft. Why had he limited his comment as compared to Ms. Jin whose feedback was rather useful? Perhaps this was due to the questionnaires sent to him via email. He could have found it difficult to using the keyboard to answer those questions and provide more feedback. Initially it was planned that questionnaires would be only be sent via emails to teacher participants. It was thought that it would be swift, efficient, cost effective and capable of reaching more teachers. However, Mr. Kenneth's response raised the question of if emailing the participants was the best way.

Sitting before a computer to fill out a survey form takes time – a teacher participant would probably need to go to his/her computer, turn it on, log on to the internet, go to his/her and account and start to fill out the form. He / She might miss the email or worse think that it was a junk mail. A simple question that we can ask ourselves is: how many times have we filled out a survey form sent to our email? For many people for sure the answer would be close to nil. After some pondering, a final decision came to use snail mail or deliver the forms personally to the teachers instead with the survey forms attached. This would definitely increase the workload of writing the teachers' name, school address, posting the forms and not forgetting the cost of stamps and envelope but in this way it would be certain that the mail would reach them. With the hardcopy in their hands, the teacher participants could choose to fill out the forms immediately or perform the task after school hours at their most convenient time and place. The only drawback foresaw would be that some participants might be reluctant to go to a post box to post their forms.

3.8.6.3 MR. BERNARD'S COMMENT

When the new draft of the cover letter and the questionnaire cum STEBI-A form were edited after the above two teachers' comments, the final draft was sent to Mr. Bernard, another teacher undertaking his PhD in education at an American university. He was requested to peruse the contents and give any feedback if necessary. Two weeks later, the forms were returned. Mr. Bernard informed the researcher that he had completed the forms effortlessly and everything in the content was comprehensible.

3.8.7 CONTRIBUTIONS OF PILOT STUDY

The pilot study contributed to the research greatly. Firstly, after the feedback of Ms. Jin, questions deemed difficult to understand were simplified into plain English as much as possible so that any teacher who received the forms would be quick to comprehend the questions and pen down their thoughts and answers immediately. Some questions found to be too invasive or personal to be disclosed to a complete stranger were edited or taken away completely - nevertheless they would be asked during the interview if the teachers agreed to answer them. This was very important because the participants needed to be at ease when filling out the forms.

One of the most important points that transpired from this pilot study was the decision to give out a monetary incentive (voucher) as suggested by Forsgren (1989) (further discussed on page 81) to teachers who took part in this study. The voucher encouraged more teachers to take part upon the receipt of the survey forms – this reduced the time sourcing for more teacher participants (if the response was disappointing) and the preparation work involved in sending them the letters. Another lesson learnt from the pilot study was the decision to withdraw the plan of relying on mass emailing the teachers with the hope that they would respond. From Mr. Kenneth's response, there was a doubt if potential participants would go through the process of filling out the forms on the computer. This decision proved to be worthwhile later when healthy responses from the participants through 'snail mail' were received.

3.8.8 ETHICAL ISSUES IN QUALITATIVE INTERVIEWING

Before the start of the data collection, a comprehensive review of the ethical issues that are paramount in all research works was carried out. The very personal, conversational nature of interview situations highlights many of the basic ethical issues of any research or evaluation method (Patton, 1990). Amongst these issues that Patton (1990) advised are:

Confidentiality - Because respondents may be sharing very personal information, it is important to honestly assess how much confidentiality one can promise. Some kinds of disclosures must be reported and respondents need to know this from the start. Also consider how the confidentiality of individuals will be preserved when the data are analyzed and reported. Related issues include who has access to the data and who "owns" it.

Informed consent - Most studies, including program evaluations, are covered by some kind of human subjects review process. This will usually require that respondents sign a permission form agreeing to participate after being informed of potential risks and benefits.

Risk assessment - It is important to consider all potential risks and include them in the informed consent process. Even though "just talking" may seem inherently harmless, people who participate in open-ended interviews may experience psychological stress, legal or political repercussions, or ostracism by peers or staff who believe that the participant has said unflattering things about them to the interviewer.

Promises and reciprocity - The issue here is what interview participants get in return for sharing their time and insights with you. Will they or their communities benefit in some way from the results of the study? If promises are made (such as copies of reports or monetary payments), they should always be kept.

Interviewer mental health - Interviewing experiences can be intense interpersonal experiences. Just as participants may experience psychological stress from disclosing more than intended or being reminded of painful experiences, interviewers may be overwhelmed by the sensitive nature of what is seen or heard, especially in home- or field-based interviews. Some form of debriefing after the interview may be necessary.

Research entails honesty, and all disciplines have a responsibility to protect the integrity of scientific knowledge (Burns and Grove, 1997). Oppenheim (1998) advised that an ethical problem can be scientific fraud or misconduct which can involve fabrication, falsification or forgery of data, or dishonest manipulation of the design.

A basic ethical principle governing data collection is that no harm should come to anyone as a result of their participation in the research. Participants will be made aware the sole purpose of this research, and no persons will have access to the data during and after the research. Participants are all volunteers; they can withdraw at any point of the research without furnishing any reasons to the author. They will not be rewarded, compensated or penalized. Although anonymity and confidentiality is of utmost importance in this research, the nature of this research which involves qualitative studies requires the use of verbatim passages from interviews to verify findings, and hence confidentiality is not completely guaranteed. Nevertheless no other persons other than the author himself will have access to field notes, audio or video tapes, compact discs, complete interview transcript, or any other data pertaining to this research. After the completion of the thesis, the data will be documented and stored on a compact disc in a secure place. All other materials relevant to the research will be destroyed.

3.8.9 TRANSCRIPTION SYSTEM

Kvale (1996) advised that qualitative interviews and their transcripts produce a large volume of material which must be condensed, categorised or otherwise interpreted and made meaningful. This may be the most costly and time-consuming aspects of the evaluation. Before transcribing of the four interviews began, the researcher read through Drisko's (2007) recommendation about the procedure. The task of transcribing was assigned to one student in junior college. The transcriber was reminded of the points that Drisko (2007) recommended and to retain the verbatim accounts of the four interviewees and refrain from doing any forms of editing along the way to make it 'sound better and fluent'. She was given 4 duplicated copies of the interviews in the form of cassette tapes and a cassette player. The completed transcripts were returned weeks later. The transcriber did a fantastic job – every instruction that was given to her was followed strictly. In fact the transcriber complained that as a result of being overly precise to what the interviewee had said, it had been an arduous task as she needed to rewind the cassette tapes many time to listen to each and every syllable or word the interviewee said on tape.

After the transcription was completed, the four tapes were listened to once more and compared with the transcripts to ensure the accuracy of the data. A possible difficulty of qualitative research is subjectivity (Kok, 2008). As mentioned earlier, the researcher was very familiar with almost all the topics in question. And because of that, it is advised to refrain from imposing any of preconceived ideas and understanding not only in the data collection and analysis, but also in the transcripts. This is what Charmaz (2003) emphasizes, "try to find out what the research participant defines as real as they live in it" (p. 523). All four participants were given a copy of their respective interview so as to confirm what had been recorded and transcribed was indeed what they really meant during the interview. The four interviewees gladly went through the transcripts, made several minor corrections and improvements, and finally approved them. Refer to Appendix 6 for the four transcripts.

3.9 DATA COLLECTION

3.9.1 RECOMMEDATION TO INCREASE SURVEY RESPONSE

Forsgren's (1989) paper on 'Increasing mail survey response rates' reported that mail surveys are one of the most commonly used methods of data collection, despite being only about half as effective as telephone surveys or personal interviews in generating responses. Such surveys have some advantages one being economical. Also a lot of information can be obtained speedily without the problems of interviewer bias and variability inherent in face-to-face techniques.

A certain degree of respondent anonymity is assured. Participants maybe more willing to "tell it like it is" on a questionnaire than they would be in an interview. Sensitive information can more easily be gathered through mail surveys where specific data are requested and records and other sources can be sought for verification. There is however one disadvantage that Forsgren pointed out and that is the potential for a low response rate.

While the interviewer has the power of a face-to-face personal contact to stimulate response, the mailed questionnaire must rely on other techniques to assure responses. Forsgren (1989) recommended including a monetary incentive to a prepaid monetary incentive is the next best single technique to increase survey response rates. Based on the researcher's own experience at the Colgate toothpaste counter, it was believed this would work too. However because of the limited budget for this research, only returned forms were given the incentive of a $10 bookshop voucher.

3.9.2 THE TEACHER PARTICIPANTS (SURVEY)

All the participants in this study went through the teacher training programme at the Singapore's National Institute of Education and hence are all qualified teachers. The anonymity of the schools and participants had been upheld. Teachers who held appointments such as Head of Department or subject head for any subject were included in this research but I had no control over whether they would complete and return the forms.

According to Trochim (2006), a probability sampling method is any method of sampling that utilises some form of random selection. In order to have a random selection method, a process and procedure must be set up to assure that the different units in the population have equal probabilities of being chosen. Bearing this in mind, a method to gather potential teacher participants was set up.

There are more than 260 government, government-aided and independent primary schools in Singapore all of which are under the wings of the Singapore Ministry of Education. Using the 'Directory of Schools' on the Ministry of Education website, the website address of all the primary schools in Singapore were identified. From those websites, 100 schools (regardless if they were mixed or single-sex school) were picked randomly. One to three teachers, male or female (disregarding his / her ethnic background or if she was Madame, Miss or Mrs), were selected randomly from the staff list on the school website. Primary 1 and 2 teachers were avoided in the selection as the teachers in these two levels were likely not to have taught Science. Teachers teaching a second language (having mother tongues like Chinese, Malay, Tamil, etc.) were also exempted as their specialist subject was language and hence they did not teach other subjects (English, Mathematics and Science).

Once the participants were identified, a cover letter (Appendix 1) informing them about the purpose of the study together with the survey forms and a return envelope were sent by snail mail to the teachers. To prove that it was not a 'hoax' to other teachers in the school and to encourage their participation, the $10 bookshop voucher was sent to them immediately upon the return of all the completed forms. All the teachers selected to participate in this survey are qualified English teachers, and hence there is no need to translate the questionnaires into other languages such as Chinese, Malay or Tamil, the official languages of Singapore. Pseudonyms have been used for the schools and participants and the latter were assured that the collected data would be held in confidence and reported anonymously.

Bandura (2006) suggested that to encourage frank answers from the teachers, researchers have to inform them that the self-efficacy scale is identified by code number rather than name. They must also be assured that their responses will remain confidential and be used only with number codes by the research staff. Additionally, researchers should also explain to the teacher respondents the importance of their contribution to the research and inform them that the knowledge it provides will increase understanding and guide the development of programmes designed to help people to manage the life situations with which they have to cope. With this in mind, all the above points are emphasised in the cover letter to the teacher participants. It was hoped that this would put them at ease while filling out the forms.

3.9.3 TIMELINE OF THE STUDY

Data collection took place between 1 July and 25 September 2009. To test the response of the participants via snail mail, only 35 survey forms were mailed out first. They were requested to return the forms in two weeks' time. If the response was poor, other means of reaching the participants would have to be explored. By the end of the second week, 4 forms were received. Though the number was small, it was very encouraging. Another 100 forms were then mailed out and the teachers were requested to return the forms by the end of the month.

To rope in more teacher participants, the researcher called and wrote to several former colleagues who had transferred to other schools. In some of the letters, 2 to 8 additional survey forms were enclosed to request their current colleagues to take part in this survey. The response was still satisfactory with several teachers returning the forms. The researcher had approached 9 teachers at the school in which he used to teach. They were requested to return the forms on the spot. A time extension was given to those who requested it and a self-addressed envelope to the researcher were provided so that they could use their free time to answer the questionnaire. Some participants completed the forms on the spot and returned them on that very day.

These participants were also presented with a $10 bookshop voucher upon completion of the forms. This is in accordance to the ethical issue that Patton (1990) raised: Promises and reciprocity - i.e. if the promise of monetary payments was made, those promises should always be kept.

3.9.4 OBSTACLES FACED DURING DATA COLLECTION

On the other hand, survey forms mailed out to teachers of different schools failed to elicit the same response as those forms that were given to ex-colleagues directly. Out of the 169 forms that were sent out, 55 copies were completed and returned to me. 2 incomplete forms were sent back because the teachers had quit the service. Surprisingly there were several ex-colleagues (in other schools) who had agreed to take part in this survey but never answered or replied to my follow-up calls and emails after a week or two. No reasons were given for their actions but it was speculated that they were unwilling (after some deliberations) to share personal and sensitive information or thoughts with the researcher.

They might also be apprehensive about sharing confidential information about the school at which they were teaching. Those extra forms with self-addressed envelopes that were sent to them were never returned. This was most frustrating as it added more time and money to the research.

Another teacher who was introduced to the researcher through a mutual friend expressed strong unwillingness to complete the forms. It was not until the researcher's friend assured her that the safeguarding of her identity was of paramount importance to me that she finally agreed to participate in the survey. Some teachers took as long as a month to complete the forms after my repeated reminders. Others who were believed would never return their forms suddenly return them weeks later. Perhaps the teachers were simply so busy with their teaching that it had taken them that long to complete them. Others could have forgotten all about it. Nevertheless it was fortunate that they did return the forms. To solicit more replies, all that could be done after the initial failure of the first 100 letters was to put more stress on the high level of confidentiality that they would receive for participating in this survey. This would ensure they could not be identified and reiterated the importance of their views being heard and possibly bringing about some of the changes.

In the course of data collecting, three advisory emails from the operation manager or head of the school were received. The researcher was informed to seek permission from the Ministry of Education before anyone could approach any of their school teachers for any survey or interview. The number of such emails was fortunately insignificant, and it did not dampen the researcher's spirit.

Despite the researcher's assurance to the participants that their particulars and answers in the forms would be safeguarded and kept highly confidential at all times, there were instances when participants insisted upon not filling out their address, telephone number or their official MOE email address. As teacher participants were hard to come by, the researcher acquiesced to their every request but appealed to them to provide their alternative email address (Yahoo, Hotmail, etc.) so that it would be easier to reach them for interview if they were required to do so.

Perhaps this omitting of their particulars was in the research's favour. If the participants are assured that their identity would not be revealed they would probably write down their true inner thoughts pertaining to their experience with Science teaching.

The teachers' refusal to take part in the survey was extended to the teachers selected for interview. A few teachers who scored the highest and lowest scores on the STEBI-A had failed to write down their contact number. A letter was drafted and posted to them to invite them for the interview but no replies were received. A few teachers declined the invitation for interview directly. As such other teachers were sought for the interview.

The teachers' (be it ex-colleagues or strangers) unwillingness to participate in the survey seems to be a common occurrence in many countries. This could be seen as almost a form of self gate-keeping because teachers are perhaps fearful of the consequences of participating (Riddick, 2010). After all, they have all taken oaths to safeguard the confidentially of information upon joining the service.

3.9.5 END OF DATA COLLECTION (SURVEY)

At the end of the data collection exercise which took about 55 days, a total of 81 forms were returned (33% of the distributed forms). Out of the 81 forms, 27 copies were returned by male teachers (30%). The success was attributed to Forsgren's (1989) recommendation to include a monetary incentive - in this case a $10 voucher - as the main reason for the rate of response. Some of the teachers had left their name or address blank indicating that they just wanted to participate in the survey and did not wish to be identified or receive the $10 voucher. One set of forms was voided as both forms were partially completed; hence 80 forms were used for the analysis. The scores of the PSTE and STOE were entered into SPSS.

3.10 PARTICIPANTS OF SEMI-STRUCTURED INTERVIEW

From the results of the PSTE subscale on the STEBI, 4 female teachers were identified for the interview. The five highest PSTE subscale scores for the female teachers were 59, 57 (4 teachers), 55 (2 teachers), 54 (5 teachers) and 53, whilst the five lowest scores were 34, 36 (2 teachers), 38 (2 teachers), 39 and 40. The female teacher who had achieved the highest point of 59 was chosen. Of all the 4 teachers who achieved the same score of 57, only one of them was selected randomly for the interview while the other 3 teachers were placed on standby incase the selected ones declined their interviews. The teaching experience of those teachers in the interviewed group ranged from six to twenty-six years.

The teacher participants for the interview were all coded with FH1, FH2, FH3, FH4, FH5, FL1, FL2, FL3, FL4, etc. FH and FL are abbreviations for "Female Highest" and "Female Lowest" respectively. "Female Highest" refers to the teachers who topped the PSTE scores while "Female Lowest" refers to the teachers who achieved the lowest scores on the PSTE. The number behind is used for identification.

3.10.1 DATA COLLECTION (INTERVIEW)

Contact was made with the selected teachers, and intention and incentive of the interview were provided. FL1 had scored the lowest in the PSTE but despite repeated assurances, she was still sceptical about confidentiality and as such declined the interview. FH1 who topped the PSTE would have been the best candidate for interview, but she had not written down her contact number or email address, and hence no contact could be made.

She also failed to reply to the letter requesting her to attend the interview. FH2 rejected the interview completely. FH4 was reluctant to attend the interview as she claimed she was moving house on that day. The suggestion of rescheduling the interview was also rejected. FH3 and FH5 were most willing to attend the interview probably due to their enthusiasm to share their experience and joy. FL1 (34) also declined to be interviewed but FL2 and FL3, both of whom scored 36, accepted the interview almost immediately. As for the STOE, FL2 and FL3 scored 33 and 34 respectively. Incidentally, 33 was the lowest score in the female STOE.

The interviews were conducted at a McDonald's restaurant, at a stone chair/table or a pavilion near the houses of interviewees, or a cafeteria. Prior to the interview, permission was sought from the participant to use a voice recorder for the whole interview. A statement guaranteeing confidentiality of the information recorded with a recorder or notepad was presented before the participants.

Each interviewee would sign the form as a form of consenting to the interview and their rights as a participant. Utmost precautions were taken to ensure anonymity so as not to put the participants into an uncomfortable position.

Each interview with a teacher began with open-ended questions such as:

- Can you tell me about your science background beginning from when you were a child?
- Which is your favorite subject to teach?
- Why do you like to teach that subject?
- What is your least favorite core subject - English, Mathematics or Science?

They were asked to reflect upon their school experiences and to talk through Science teaching/learning situations. They were also asked to think aloud about their responses to the questionnaire and also to add any other opinions they had about the teaching and learning of Science. During and after each interview, the researcher's impressions of the interviewees were written down.

The four interviews were conducted smoothly in a period of two months; in fact they were more successful than expected. The teachers involved were most forthcoming and that helped me to learn more about their experiences as Science teachers. The interviews were transcribed immediately after each session.

3.11 SIGNIFICANCE & OUTCOME OF STUDY

It was hoped that this study would contribute to the existing body of knowledge by increasing our knowledge of:

- Whether female primary science teachers in Singapore have low or high science teaching efficacy beliefs. This knowledge will be valuable to the MOE and NIE Science curriculum planners for teachers and the school heads where the training of female Science teachers is concerned so as to address the unique needs of primary female Science teachers. Special support for the female teachers is imperative as the majority of elementary teachers are females and have the important task of training Singapore's future Scientists, Engineers, Technologists and those in related disciplines.

- Whether Singapore female primary Science teachers likewise have negativity towards Science. From their responses they wrote in the forms and through the 4 interviews with the teachers, we should gain a deep understanding.

- Whether Singapore male and female teachers believe that they have the necessary training/education to teach Science.

- Learning what experiences the teachers had in the past that made him/her believe that he/she could teach Science well and who the teachers model themselves on as a Science teacher.

- Identifying barriers faced by Singapore primary Science teachers that impede optimum Science teaching.
- Identifying enablers that assisted the Science teachers in optimising Science teaching.

3.12 RESEARCH HYPOTHESIS

With the corpus of extant evidence as presented in the literature review, it was hypothesised that female primary Science teachers in Singapore possessed lower Science self-efficacy than their male counterparts in terms of their Science self-efficacy. The female teachers could point out limited time for Science instruction, limited content knowledge and limited resources as their barriers in their Science instruction. In addition, the former would probably rank English above Mathematics and Science as the subject that they had the most confidence to teach and teachers of both genders would agree that male teachers are better Science teachers.

3.13 CHAPTER SUMMARY

In this chapter the mixed-methods approach, including the strengths and weaknesses of different research traditions, approaches and strategies, and the different ways in which methods can be mixed are presented. In addition the different philosophical, epistemological and ontological positions held by qualitative and quantitative approaches to research and the contradictions which may arise by combining these approaches are explained. All the research instruments available for teacher self-efficacy are reviewed, and the explanation of how the researcher finally arrived at adopting the Science Teaching Beliefs Instrument (STEBI - A) for this research is given. The STEBI is used to measure Personal Science Teaching Efficacy and Science Teaching Outcome Expectancy, and research that had used the STEBI is presented. Explanation is given on how the present study would be conducted by using STEBI-A, survey questions and semi-structured interviews. Next the interview procedure and the questions that the teachers are requested to answer are listed out. The pilot study which involved 3 teachers contributed significantly to the survey questions and procedure. A review of ethical issues in qualitative interviewing was done before the data collection was carried out. Next obstacles faced during data collection and its results are stated. Finally the significance and outcome of the study and the research hypothesis are presented.

CHAPTER 4

DATA ANALYSIS & RESEARCH FINDINGS

4.1 INTRODUCTION

This chapter is divided into two sections. In the first section, the purpose of analysing the data is explained. Next the results of the STEBI-A (PSTE & STOE) and the teachers' responses to the survey questions are reported. Data from the PSTE subscale were used to select 4 outlier teachers for the interviews. Their responses to the questions are presented in Section 2. Using the interview with the 4 female teachers who had scored the highest and lowest on the PSTE, a better understanding of their experiences as primary Science teachers was gained.

4.2 SECTION 1

4.2.1 PURPOSE OF ANALYSIS

The purpose of the analysis was to determine whether Singapore female primary teachers possessed higher or lower Science self-efficacy when compared to their male counterparts. Another purpose of the analysis was to find out the barriers and enablers that Singapore female Primary teachers identified in the effective teaching of Science. Through the analysis of the qualitative and quantitative data, we gained informative insights into the influences of teacher beliefs (positive or negative) about their own abilities in the teaching of science.

4.2.2 DEMOGRAPHICS OF SAMPLES

Table 1 presents demographics of the 80 teacher participants that are made up of 27 male and 53 female teachers. Their ages range from 21 to 30 years old (3 teachers are unknown) with a minimum teaching experience of 5 years. 51 of the teachers had a bachelor degree, 7 had a master degree and 19 had an 'A' level or diploma certificate.

Table 1

Demographics

Independent variable	Category	Number
	Male	27
Gender	Female	53
Age	21-30 years	27
	31–40	31
	41-50	7
	> 50	4
	Unstated	11
Years of teaching	< 5	34
	6-Oct	27
	Nov-20	10
	21-30	3
	> 30	3
	Unstated	3
Years of teaching	< 5	48
	6-Oct	21
	Nov-20	5
	21-30	1
	> 30	2
	Unstated	3
Highest qualification	Master Degree	7
	Bachelor Degree	51
	A-level / Dip / Cert in Ed	19
	Unstated	3
Total Participants		80

4.3 INTERNAL CONSISTENCY RELIABILITY

To assess the consistency of results across items (i.e. different questions) of the PSTE or STOE scales, Cronbach's alpha statistic was used as a measure of internal consistency or reliability of the PSTE and STOE scales.

4.3.1 PSTE SCALE

Table 2

Personal Science Teaching Efficacy Belief Scale

Item Number	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q2	45.01	33.35	0.26	0.84
Q3	45.79	27.84	0.64	0.82
Q5	45.61	30.77	0.53	0.83
Q6	45.83	30.27	0.47	0.83
Q8	45.25	30.65	0.51	0.83
Q12	45.35	32.26	0.41	0.84
Q17	45.59	30.14	0.53	0.83
Q18	45.39	32.90	0.41	0.84
Q19	45.9	27.33	0.62	0.82
Q21	46.38	26.87	0.56	0.83
Q22	45.43	30.70	0.51	0.83
Q23	45.01	32.49	0.37	0.84
Q24	45.53	29.62	0.62	0.82

Cronbach's Alpha on PSTE Scale 0.84

4.3.2 STOE SCALE

Table 3

Science Teaching Outcome Expectancy Scale

Item Number	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
S1	36.44	23.06	0.42	0.72
S4	36.44	23.52	0.42	0.72
S7	37.32	22.25	0.42	0.72
S9	36.35	23.12	0.41	0.72
S10	37.89	22.79	0.45	0.72
S11	36.46	23.75	0.51	0.72
S13	36.75	23.28	0.34	0.73
S14	36.69	22.52	0.41	0.72
S15	36.71	21.88	0.51	0.71
S16	36.39	25.18	0.18	0.74
S20	36.74	24.48	0.15	0.76
S25	37.34	21.62	0.39	0.73

Cronbach's Alpha on STOE Scale 0.74

Table 2 shows the Internal Consistency for the PSTE scale was examined using Cronbach's alpha. The alphas were very high -- 0.84, indicating strong internal consistency among the 13 questionnaire items. Table 3 shows the Cronbach's alpha of the STOE scale as 0.74 which is moderately high and indicates reasonable internal consistency among the 12 questionnaire items.

4.4 CORRELATION BETWEEN PSTE & STOE

A Pearson correlation coefficient was computed to assess the relationship between the between PSTE and STOE. There was a positive correlation between the two variables, $r(80) = 0.41$, $p < .01$. Overall, there was a moderately low, positive correlation between PSTE and STOE.

4.5 Quantitative analysis of gender differences for each scale

Table 4

Mean scores, standard deviations and standard errors for scores on Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) by Gender

	Gender	N	Mean	Std. Deviation	Std. Error Mean
PSTE	Male	27	51.33	5.39	1.04
	Female	53	48.32	5.99	0.82
STOE	Male	27	40.56	5.69	1.10
	Female	53	39.92	4.95	0.68

The means in Table 4 reveal that although Male teachers (M=51.33, SD=5.4) reported significantly higher PSTE scores relative to female teachers (M=48.3, SD=6.0), an independent samples t-test showed that the difference was not significant ($t(78)=2.20$, p=0.45). For the STOE, again Male teachers (M=40.6, SD=5.70) scored higher than females (M=39.92, SD=4.95) but unsurprisingly, given the very small difference between the means, the difference was not significant ($t(78)=0.51$, p=0.95). The evidence therefore suggests that there was no difference in mean scores of PSTE or STOE between males and females.

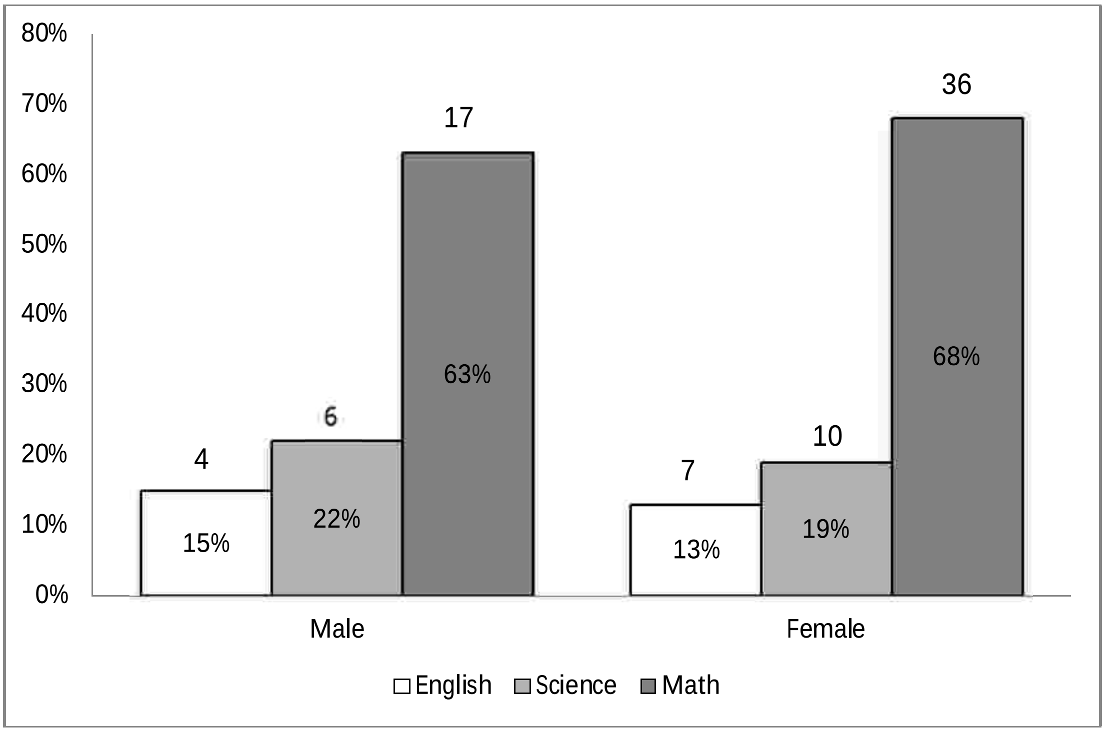
CONCLUSION

The internal consistency for the PSTE scale indicated strong internal consistency among the 13 questionnaire items. As for the STOE, it indicated reasonable internal consistency among the 12 questionnaire items. A positive though moderately low correlation was found between the PSTE and STOE scales. Analysis of the Science Teaching Efficacy Belief *Instrument* (STEBI - A) using individual t-tests show that male teachers have higher Personal Science Teaching Efficacy (PSTE) mean score than female teachers. There is no difference between mean scores of males and females for Science Teaching Outcome Expectancy (STOE). But multiple t-tests using Bonferroni correction show no evidence for differences in mean scores of PSTE or STOE between genders. Nevertheless the results are close to significance and the effect of gender should not be discounted.

4.6 RESPONSES OF TEACHERS TO THE SCIENCE SURVEY

The responses of the 80 teachers to the survey questions were analysed and reported upon below:

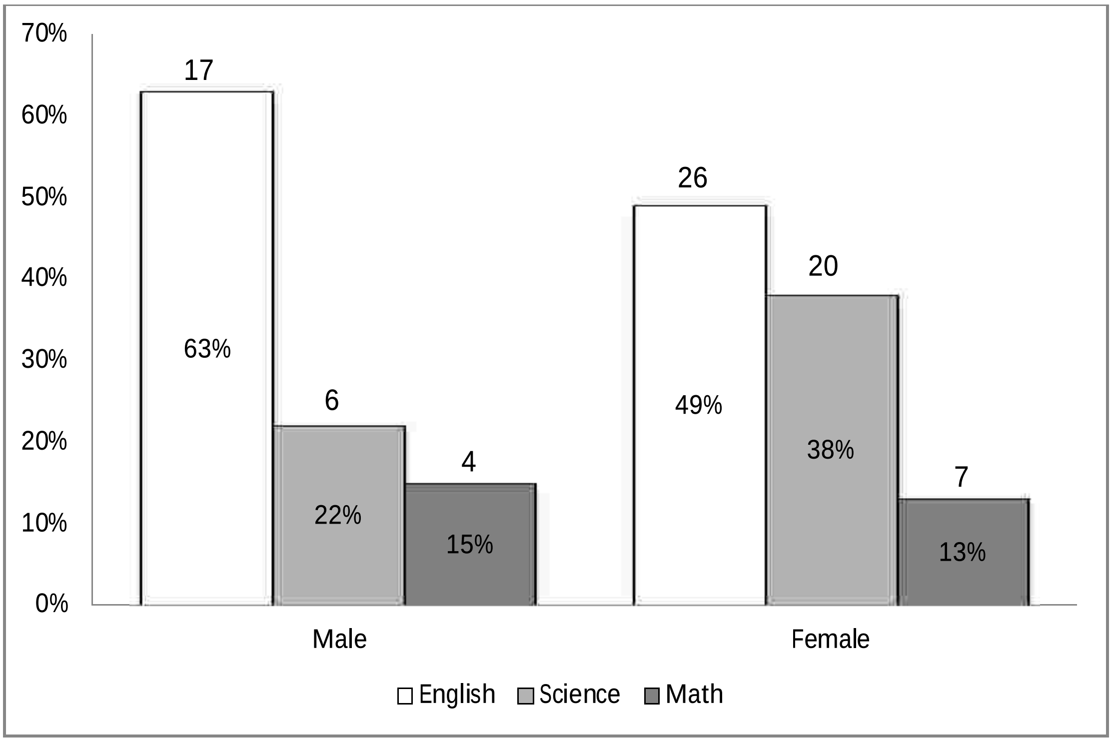
GRAPH 1



4.6.1 Which is your most confident subject to teach?

Graph 1 shows the teachers responding to the above question 'Which is your most confident subject to teach'. 17 male and 36 female (63% of the male and 68% of the female teachers) teacher participants mentioned Mathematics as the subject that they had the highest confidence to teach. Science was ranked second with one-fifth of the teachers, 6 for the male and 10 for the female teachers (22% of the male and 19% of the female teachers) agreeing. English was ranked the lowest by the teachers with 4 for the male and 7 for the female (15% of the male and 13% of the female teachers) teachers.

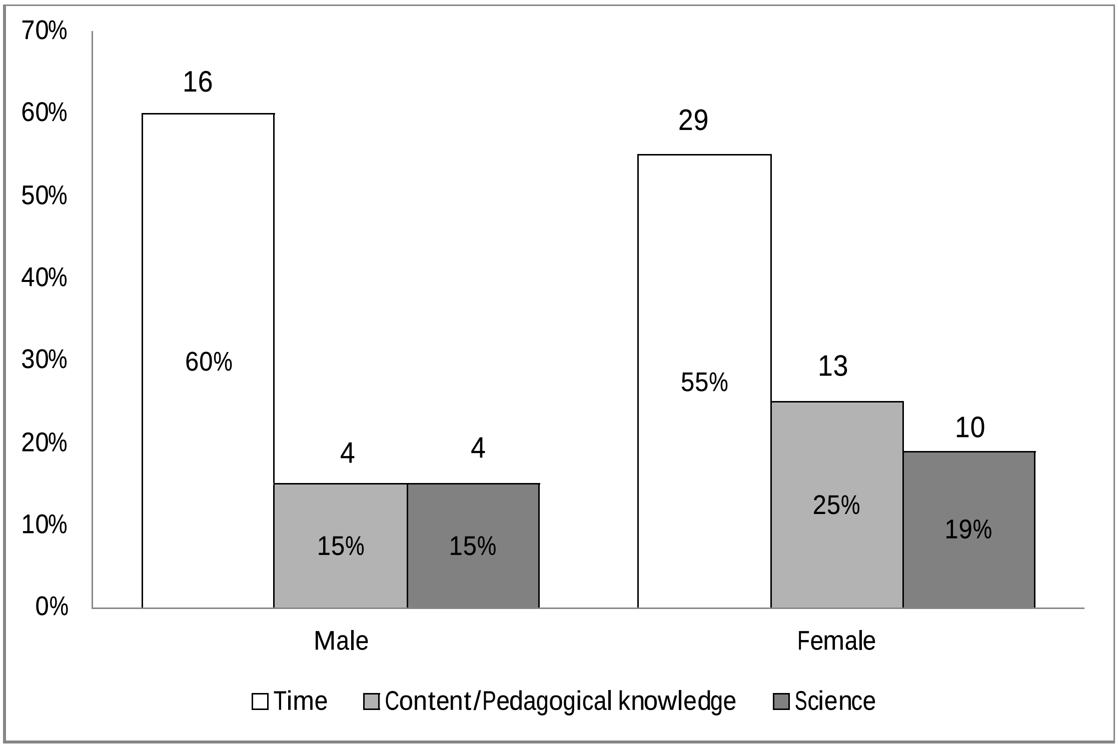
GRAPH 2



4.6.2 Which is your least confident subject to teach?

Graph 2 shows the number of teachers who had the least confident to teach English, Mathematics and Science. Again both genders, 17 male and 26 female teachers (63% of the male and 49% of the female teachers) ranked English as their least confident subject to teach. 6 male and 20 female teachers (22% of the male and 38% of the female teachers) ranked Science as their least confident to teach. Only 4 male and 7 female teachers (15% of the male and 13% of the female teachers) ranked Mathematics as the least confident to teach.

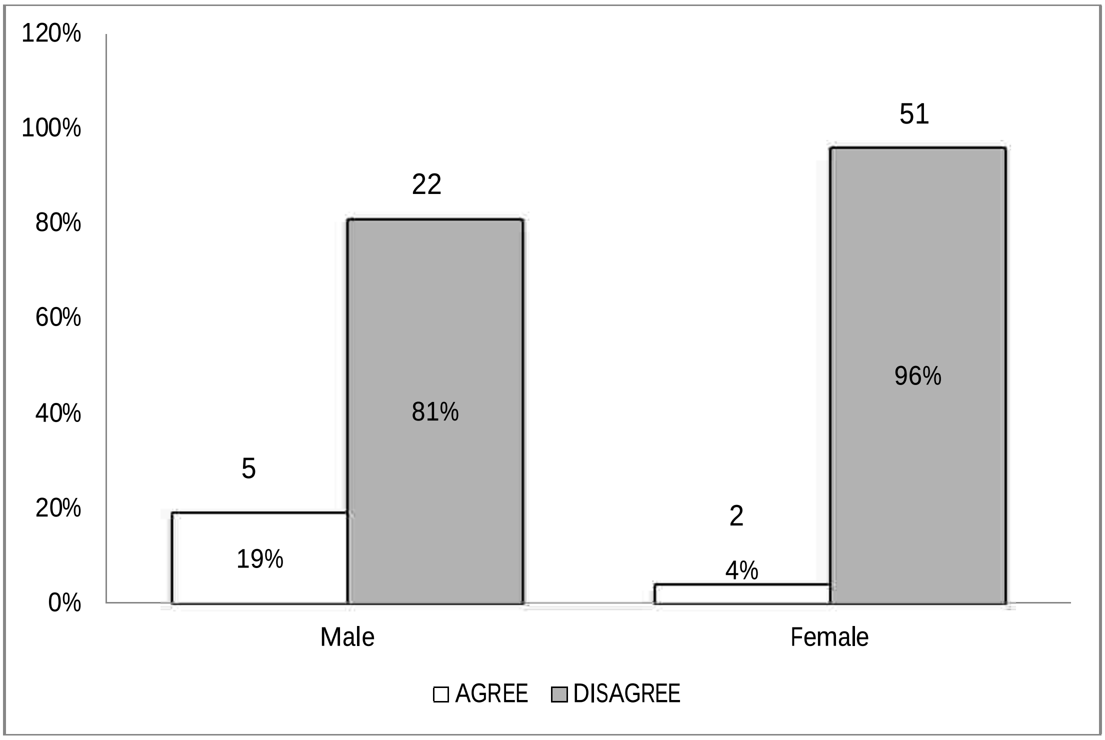
GRAPH 3



4.6.3 What are the major obstacles you face that stand in your way to optimum science teaching?

Graph 3 shows that the limitation of time for Science teaching had the most mentions when the teachers responded to the factors that stood in their way to optimum Science teaching. Altogether, 45 teachers, 16 males and 29 females (60% of the male and 55% of the female teachers), mentioned it as the major obstacles. 17 teachers , 4 males and 13 females (15% of the male and 25% of the female teachers) mentioned that they lacked content/pedagogical knowledge. 14 teachers, 4 males and 10 females (15% of the male and 19% of the female teachers) mentioned that lack of Science resources was the problem they faced. 4 teachers cited other obstacles that impeded their Science teaching.

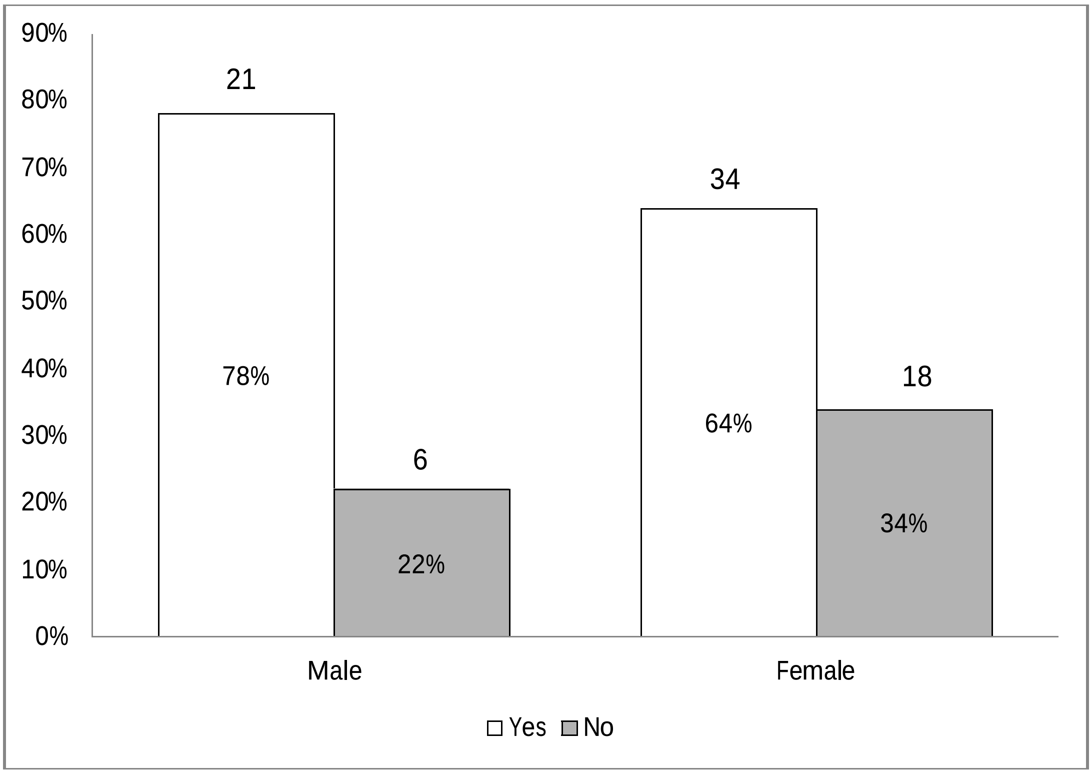
GRAPH 4



4.6.4 As a male /female, do you think a male teacher can teach science better than a female?

Graph 4 shows the result of male and female teachers responding to the question "As a male / female, do you think a male teacher can teach Science better than a female?" The data shows that 73 of them of the 80 teachers with 22 male and 51 female teachers (81% of the male and 96% of the female teachers) disagreeing that male teachers could teach Science better than the other. 5 male and 2 female teachers agreed to the above statement.

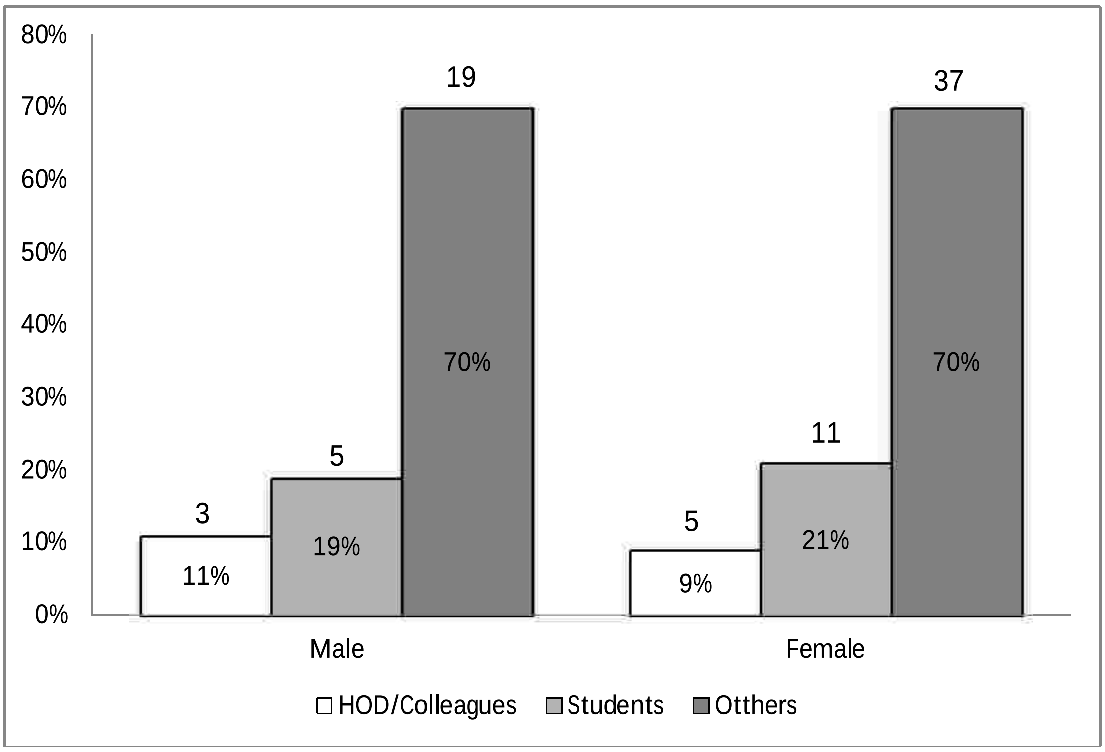
GRAPH 5



4.6.5 Do you think you have the necessary / adequate training / education to teach science?

Graph 5 shows the results of teachers responding to the question, "Do you think you have the necessary / adequate training / education to teach science?" When the 80 teachers were asked to respond to the above question, about one third of the teachers, 6 males and 18 females (22% of the male and 35% of the female teachers), indicated that they did not have the necessary or adequate training or education to teach Science. These numbers show that one third of the female participants and less than one quarter of the male participants believed that they did not have the necessary training or education to teach Science. One female teacher had indicated she was 'neutral' to the above question.

GRAPH 6



4.6.6 What was the thing (praise, feedback, etc.) you received from someone in the past that made you believe that you could teach science well?

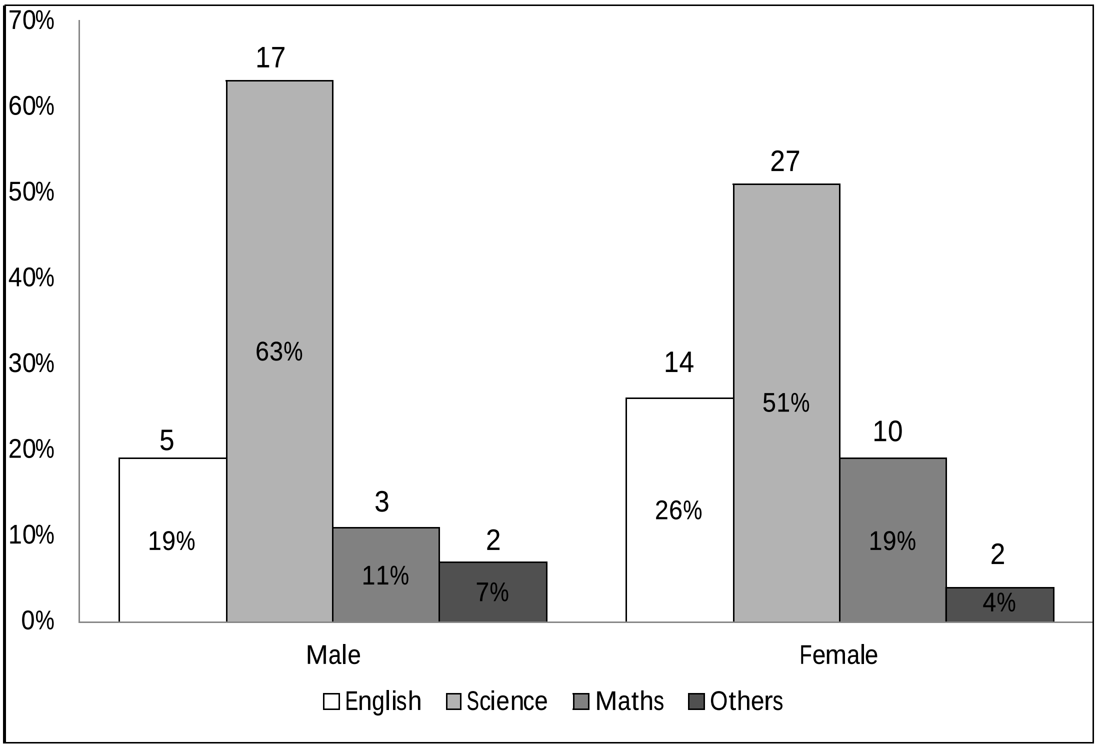
Graph 6 shows that out of the 80 teachers, only 8 teachers mentioned that either a colleague(s) or a supervisor (HOD, Vice Principal or Principal) had praised him/her making them believe they could teach science well. Out of the 8 teachers, only 5 are females (9% of the female teachers). Most of the positive feedback that they received was from their own students. A total of 16 teachers stated that their pupils had given them most of the motivation. Out of the 16 teachers, 11 of them were females (21% of the female teachers). Those female teachers stated that the students' satisfactory science results, students understanding what had been taught, students' positive feedback that they liked their science lessons, and pupils starting to question her beyond what she had taught them as confirmation that they could teach science well. Two female teachers reported that they had received the affirmation from a member (brother or father) in their family, while 6 teachers quoted an ex-teacher or Science lesson(s) / workshop(s). The rest of the teachers quoted other miscellaneous factors like 'passion in the subject'; 'the spirit inquiry in all of us'; 'interest'; 'having scored well in school for science'; 'personal belief'; 'ability to perform experiments in front of pupils confidently'; 'experience'; etc.

4.6.7 How did / does the science department help you to raise your science-teaching efficacy?

Almost every of the teachers' school organised some forms of professional development programmes for their Science teachers. 64 teachers (45 females) mentioned that their school organised workshops, while 35 (24 females) teachers mentioned that their schools held sharing sessions. During professional sharing sessions, teachers shared experience, resources and teaching strategies. They also discussed subject mastery & related issues which included reviewing Science activities and concept teaching.

(Note: Several teachers mentioned more than one form of professional development programmes)

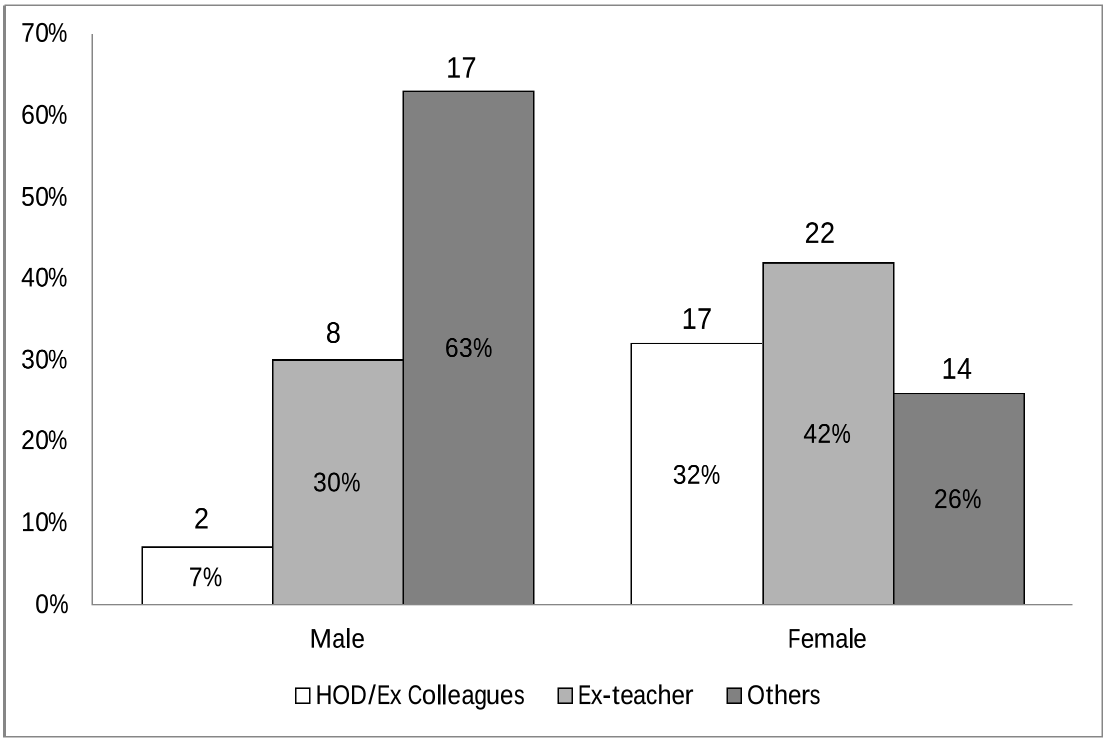
GRAPH 7



4.6.8 Which is the subject that you consult your colleagues about most frequently?

Graph 8 shows that more than half of the teachers (44 teachers) in this research indicated that Science was the subject that they consulted their colleagues most frequently. From those 44 teachers, 27 were female and 17 were male teachers. English was second with 19 teachers (14 females) indicating it as the subject while 13 teachers (10 females) indicating that Mathematics in their answer. 3 teachers had written down 'nil' for all the subjects and 1 teacher had given an irrelevant answer.

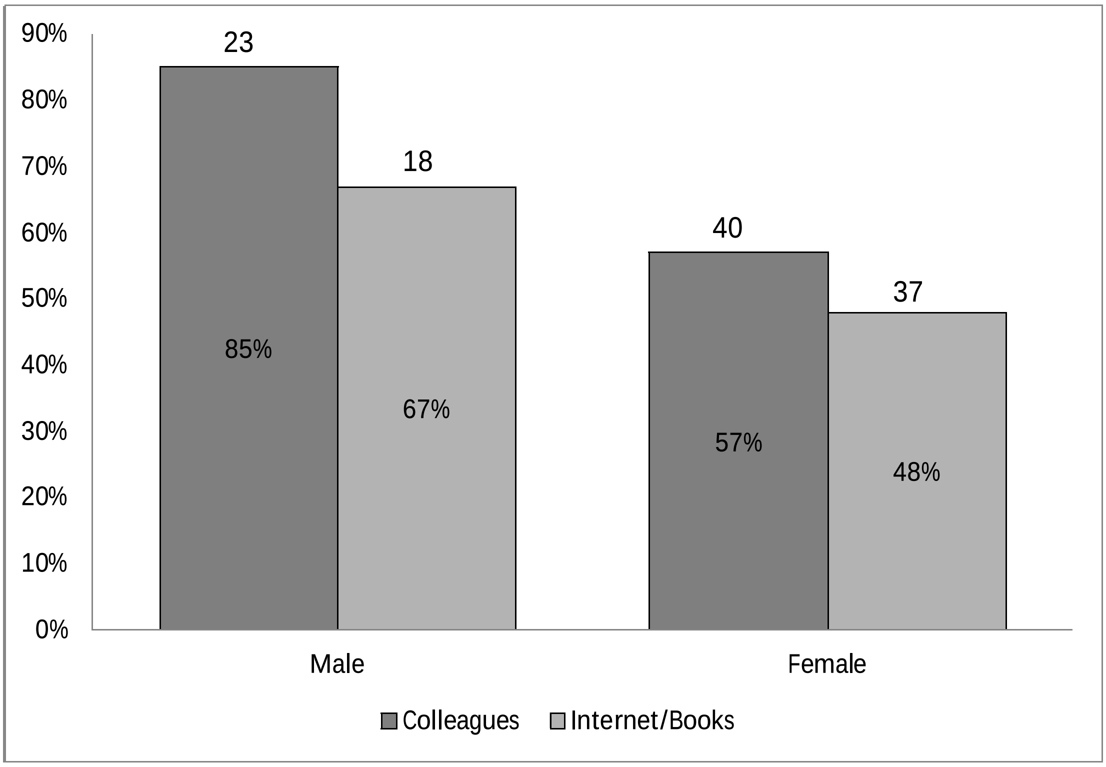
GRAPH 8



4.6.9 Who (if anybody) do you model yourself after as a science teacher?

When responding to the above questions, 19 teachers wrote that they had been inspired by their current or ex-colleagues including HODs. In fact, of the majority of those teachers who wrote an 'HOD' or a 'colleague', 17 of them were female teachers; there were only 2 male teachers. 30 teachers (8 males and 22 females) wrote that an ex-teacher (primary, secondary, junior college, college or NIE lecturer) had inspired them as a Science teacher. For 'others', the 31 teachers' (14 females) answers ranged from mostly 'none' or 'nil' to 'Jesus', 'pupils' and 'myself'.

GRAPH 9



4.6.10 What did / will you do when you encounter trouble or problems in teaching science?

Graph 9 shows that out of the 80 teachers, 63 mentioned that they would seek the help of a colleague if they encountered any problem in teaching Science. Of the 63 teachers, 23 are male while 40 are female teachers. There were 37 female and 18 male teachers who mentioned check the 'internet' or 'read up books'.

(Note: Several teachers mentioned more than one form of professional development programmes)

4.7 SECTION 2

4.7.1 INTERVIEW WITH TEACHERS OF LOW SCIENCE SELF-EFFICACY

4.7.1.1 CANDICE FL2

4.7.1.1.1 BACKGROUND OF INTERVIEWEE

Candice is a 30-year old teacher with a Bachelor degree in Applied Science majoring in Computational Finance. The word 'Science' has no direct link to the Science I have defined earlier on. Also known as Financial Engineering, she explained that computational finance is a process that relies on the application of several factors in order to arrive at conclusions regarding such matters as investments in stocks and bonds, trading and hedging on stock market activity.

Candice had scored 36 on the PSTE, the second lowest on the STEBI – A. As mentioned earlier on, scores on STOE, the second factor of the STEBI, have also been related to the quality of teaching in science. Teachers with low scores on STOE were rated as less effective in Science teaching, rated themselves as average and were rated as poor in attitude by site observers (Enochs et al, 1995). Candice had also got a very low score of 34 on her STOE against other teacher participants in this research further confirming her low self-efficacy for teaching Science.

Candice was teaching a primary 2 class in a school in the western part of Singapore. Her experience as a primary teacher is less than 5 years and her experience as a Science teacher was less than one year. She was not assigned to teach Science at that point of interview. The interview with her took place at a McDonald's near her home one Saturday afternoon during the school holidays in 2010. The venue was based on her request and at her convenience. I gave her the interview consent form and requested that she read its content carefully. She agreed with it and signed on the letter. A copy of the form was given for her retention. At first she was a little uneasy about the fact that I would be audio-taping our conversation. After my repeated assurance that her identity would be kept confidential and that if she wanted me to erase any part of the recording I would be glad to do so, she became more relaxed and the interview began.

4.7.1.1.2 ABSENCE OF ROLE MODEL IN SCHOOL

The interview began with the researcher asking about her Science background since she was a child. She could vaguely remember about her primary Science education, and could not identify any teacher who had been influential. She took Pure Chemistry and Pure Physics in secondary school. When I questioned her about her choice of the two Science subjects, she stated that they were compulsory subjects, and Biology was not offered to her.

Unlike Physics, she liked Chemistry and found it to be "interesting". I asked what she meant by "interesting" but she did not seem to be able to give me an answer. Again she could not point out any special teacher who was influential on her as a Science teacher. I probed further and asked if besides teachers did she have anyone in mind who had inspired her in her Science. The answer was negative again. From the first part of the interview, I gathered that Candice did not have any role-model in her younger days when she contacted Science.

4.7.1.1.3 SUBJECT MAJORS IN SCHOOL

We then moved on to her choice of subject major in college. Since she found Chemistry to be "interesting" I was curious to know why she had not taken up Chemistry in college as one of her majors or minors and had instead taken up finance computation. She replied that it was one of the popular majors and that was why she had taken it. In college it was compulsory for the students to take up a Science module. She would not have enrolled in the course if it was not compulsory. She also questioned with much irritation the fact that why the college had to make them take up that course. Nevertheless she had found some parts of the module interesting.

We then moved on to her stint at the National Institute of Education. I was curious again if there was again any lecturer who had inspired her. Her answer was yet again negative. She lamented that NIE did not prepare the pre-service teachers well enough. Everything was in done a rush and there was no Science content knowledge enforcement. When I asked her to suggest a way that the National Institute Education could raise the self-efficacy of pre-service teachers, she paused for a while and said that they would not be able to do much. But she did come out with a laconic suggestion that perhaps the Science courses for pre-service teachers at the NIE could be over a longer period of time. This is so that more content knowledge, hopefully, could be gained through this extended period – after all Science to her was a "big subject". To her, what she learnt at NIE was "not real life enough".

Candice's practicum lasted only ten weeks and she was only able to concentrate on Primary 5 Science. She relied a lot on past knowledge that she had learnt in primary school to teach her students.

4.7.1.1.4 BARRIERS FACED IN THE SCIENCE CLASSROOM

I then moved on to querying her on her teaching practice of Science. In the classroom Candice either read from the textbook directly or used PowerPoint to represent the information (which normally came from the textbook) so that she did not need to read from it. There would be more pictures but the content was about the same as the book. She moved on her problem she faced while teaching Science, and time was the number one factor:

> If you see the plan, the lesson schedule given by the textbooks is a lot to cover. I was teaching P3 and there were only 3 periods per week. So I needed to cover a lot of things within that 1 period. Actually I was really rushing. Fortunately, I was the form teacher so in the end, in order to finish the curriculum for the exams, I managed to finish my English syllabus, my Maths syllabus, and therefore I had time for science. In fact I stole time from [other subjects]. 3 periods (for Science) is not really enough, so if they want to do something at the kids' pace, we need a lot of time, especially experiments. Even an adult doesn't guarantee a sure success in an experiment that was done so many times by other people. But you still need time, so what's more for the kids.

As time was a main factor, she confessed that she actually had to give the answers to her students directly for work done in school.

Candice also mentioned that she could not teach experiments well – she particularly remembered two failed experiments. One of them was the life cycle of a beetle. She had kept some of the said insects to serve as a demonstration. The animals died as they grew from one stage to the next stage. She also failed to demonstrate the experiment on the pollination of flowers to her class.

One of the most dreadful events as far as Science was concerned was when Candice was requested to set the primary 5 Science examination papers. She was at a total loss and questioned why she had been asked to set it as she was not teaching Science that particular year. Due to her lack of content knowledge in Science - let alone setting a set of Primary 5 Science examination papers - she was forced to refer to past year exam papers of other schools. From those papers, she modified the questions without much knowledge as to whether they were correct or not.

At that point of the interview, she expressed her gratitude to the school that she had not been asked to teach Science that year and was posted to teach primary 2 as this level did not have Science as a subject. When asked about the possibility of the school telling her to teach Science after the holiday (it was a school holiday at that time), she became stunned and speechless. She said that she would not know how to react. Her school culture was not geared towards Science. In another word, the environment was not supportive. She disclosed that workshops for Science teachers were only arranged once in a while.

Amongst the four interviews, Candice's was considered the shortest as many of her answers were terse. Many times, I prompted her to divulge more about her Science experience but got little. This was probably due to the fact that she really had nothing to share about her Science teaching. Though she had 5 years of teaching experience, she only taught Science for one year. This could also be one reason why she had got such a low score on the STEBI-A.

4.7.1.2 ISABELLA FL3

4.7.1.2.1 BACKGROUND OF INTERVIEWEE

Isabella is a 28-year old teacher who graduated with a diploma in internet computing from a local polytechnic. She was considered one of the most forthcoming interviewees who shared every nitty-gritty aspect of her teaching experience. Her experience as a primary teacher was more than 6 years while her experience as a Science teacher was more than 3 years.

At the point of interview, she was not assigned to teach Science to any level as she had requested to teach Physical Education. Isabella had also achieved a very low score of 36 on her PSTE and 33 on her STOE. Similar to Candice, the results showed her low self-efficacy for teaching Science.

The interview with Isabella took place at a stone chair near her in-law's apartment during the school holidays. It was an idea place as the environment encouraged her to communicate freely. The whole interview took approximately 45 minutes. Again, before the interview, the same procedure I went through with the previous interviewee was followed.

4.7.1.2.2 SCIENCE BACKGROUND

Similar to Candice, Isabella was asked about her Science background. She disclosed that during her primary school days, Science, as compared to English and Mathematics, was considered as an unimportant subject for the Primary School Leaving Examination or better known as PSLE:

> So then (years ago) science was very simple, like living things and non-living things, whether fruits have seeds or not seeded, how many seeds there are. That was the impression I had of science… I think at that time (Science) was really more textbook based.

During Isabella's earlier Science education, there were no primary school teachers who had left any deep impression on her that she could emulate as a Science teacher. In fact, she divulged that she had no recollection about her primary Science lessons and could not remember any particular time when she had a very interesting Science lesson.

Isabella then went on to tell me about the high expectations of a Science teacher and how she felt about it:

> You look at the teachings now, as a teacher, you have to do more. But last time was more of a chalk and board kind of thing. I will just write on the board and talk, and go through the things from the textbook. And if I had time, I would just bring the pupils to the lab to do some experiments. If not, I would just do it in class and that was it… Last time, science wasn't that broad yet. So if I didn't know that much, I could still "smoke" my way through. I could still try to say something which sounded logical but it might not be right. But for now, I think science has taken on a different dimension because we are studying on genetics and DNA and things like that. And you can't try to bluff the students because there is the availability of technology like the internet. They can just Google it and go and read up on their own. They can know that actually the teacher is not telling them the truth. I think last time was more constrain and context, but now it is much more enlarged. So I think the teachers feel the stress to read up more than what you need to know. In the case when pupils ask you questions, you won't look silly in front of them.

Things were a little better when Isabella attended secondary school. She took up Physics and Chemistry but the school did not offer Biology. There were only two secondary school Science teachers whom she remembered, but the reason for remembering the first one was not because she was a "good Science teacher" but rather she remembered her because she was a disciplinarian. The other Science teacher was the subject head whom she felt to be "very motherly". This teacher taught her Chemistry and she was inspired by her:

> She is the subject head of science, Biology. I like her for the fact that she's very motherly … (and) very nurturing. Whenever there were questions we encountered or had any difficulties, she would not hesitate to help us. You could even stay back after school to go and ask her questions after that. I think that is why I love Chemistry, all the different formulas and components. That really helped me.

When I prodded Isabella how she had done in her "O" level Chemistry to ascertain if that "motherly" figure had inspired her so much as to translate into good results, she replied that she could not recall anything. She mentioned that she was against Science because "Science is a practical subject". In the Singapore context, Science is not important. Though she disclosed that the National Institute of Education did not prepare teachers for Science teaching, she believed that the onus of being a good Science teacher was still on the teachers who must do a lot on their own.

4.7.1.2.3 RECOMMENDATION TO RAISE SELF-EFFICACY

When Isabella was asked to suggest a few ways to the NIE to raise the self-efficacy of Science teachers, she referred to the NIE lecturers and recommended:

> I suppose getting experienced science teachers in the primary school to come and actually teach the teacher students. I do understand that many of the professors in NIE are very academic and sometimes when you have not been to a school to teach, you don't know how difficult it is to find the time to really teach a good proper lesson. In NIE, we were taught to do the lesson planning and you crack your head for the next one two hours trying to think of a lesson which you just teach it and that's it... But if you had been outside teaching, you realised that it is really difficult.You want to put in a lot of activities and so on, but there are a lot of other factors involved. You may want to do an activity but it may not be a conducive time. It may be after recess, so they are very tired, or at the end of the day, when the kids are just looking forward to go home or early in the morning where the kids are just being very sleepy; there are a lot of factors. There are many factors which we need to consider because we can't just think that oh I am a teacher, I want to teach this and so it will flow like this because there are always some impromptu things that will pop up.

Isabella also recommended that the mentor whom the pre-service teacher observes in school during their practicum should be carefully selected:

> [NIE] assigns teachers to go out to do practicum to observe their mentors teaching English, Maths or Science or whatever subjects. I am not saying that all teachers are bad or all teachers are good, but I think whatever subject is your AS subject or your content subject, I think the school or maybe NIE should make the arrangement that the school appoints a good English teacher for the student teacher to go and observe. If not, then sometimes doing practicum seems to be like a waste of time because you are observing me, I am a greenhorn and you give me feedback of what I should change and it becomes a vicious cycle. In the end, I find that it doesn't benefit people in a way because we become very task oriented and becomes like I'm your mentor, I will observe you, you got to learn from me. It's not dynamic in a way.
>
> I know of this teacher in my primary school. She is still a science teacher there, I think a science HOD and she was on the papers once the last few years … They talked about her being a very good science teacher and things like that. I think these people deserve the recognition, in a form of like students who are going to

> become teachers, they should go and observe them and find what is the key to their success of being a good science teacher…

As for the suggestions she gave to schools to raise the Science self-efficacy of female teachers, Isabella strongly believed that the onus was still on the teachers to read up more on Science-related issues and those that they were going to teach to their students. This was a point that she reiterated a few times throughout the interview. For schools she proposed that schools subscribe to Science magazines or journals, and forward Science-related emails. They could also purchase books on how to teach Science more effectively. Schools could invite Science teachers who are role-models on teaching courses.

4.7.1.2.4 MOST PREFERRED SUBJECT TO TEACH

Mathematics was the subject that she had the most confidence to teach. Ironically she had hated Mathematics since she was young. It is a subject that could be done with a lot of activities to help the pupils visualise. She found English to be easy but felt that technical parts like grammar made it difficult to visualise and learn in a fun way. Science was her least preferred subject and she attributed it to how one was brought up – the family played a crucial role.

> If you come from a family that is English speaking and they encourage a lot on science, reading up then (may) help in your interest… I came from a Mandarin-speaking family and my parents are not highly educated. So they can't encourage me in science in a sense, so I think upbringing also plays a part.

4.7.1.2.5 TEACHER AS A FACILATOR IN THE CLASSROOM

Isabella believed that students had the necessary Science knowledge already before they entered the classroom. For her, teachers were just facilitators in a Science classroom and it was up to students to read up.

Isabella did not like taking any credit for any success story of her students in her Science class and attributed the success of her students to their own effort and their parents' contribution:

> I feel that teacher only meets the students about 3 hours a day. And sometimes teachers will go to teachers and say wow your class did very good, you must have been a very good teacher and sometimes I feel that no you know. It's the students putting in more effort and the parents. I mean I see you 3 hours a day (and) how much can I help you. You have to do all your ground work back at home. I am merely a facilitator to give you information that's all.

When Isabella taught Science 6 years ago, she considered it smooth sailing but it took a turn for the worse in the year before, 2009. In 2010, the primary Science syllabus was revised. Based on the MOE website on the new syllabus, the Science teacher was to be the leader of inquiry in the Science classroom and the person who imparts the excitement and value of Science to their students. They are facilitators and role models for the inquiry process in the classroom. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Isabella explained the rigor of the new syllabus and the problem she faced:

> I taught science and that was about six years back. Then the science syllabus had not changed into what we have right now, (like) the themes, the thematic patterns. It was easier to teach because we have feedbacks from parents that we should teach what is in the textbooks and for examination... My second encounter was last year [Year 2009]. I had quite a hard time because there were lots of experiments that needed to be done and I the content had expanded to an extent that I found it overwhelming to actually deal with it because I had to read up.

4.7.1.2.6 LACK OF MENTOR IN SCHOOL

When I asked her about the guidance her mentor in school had given her, she revealed that she did not receive the necessary support she needed and she was left to her own devices to seek help when she faced any problems in her Science teaching:

> My mentor wasn't a science person. There was no way she can help me because sometimes when you are assigned to reporting officers, who may not be teaching the subject you need help in, then you have to take your own initiative to go and find out from other colleagues who are those who are very skillful in teaching science.

4.7.1.2.7 LIMITATION OF TIME

Besides the absence of a Science mentor, Isabella also spoke about other problems that she faced while teaching Science - one of which was limited time.

> I was teaching P5. Science was only 4 periods a week. One period is 30 minutes and usually for my school, we put 2 periods together, so that's one hour. We only have 2 hours of science lesson per week… There are lots of experiments to be done [for P5 and P6]. You can't possibly take one hour to do an experiment because it will definitely spill over; you need to prepare… [P3 and P4 classes were] quite ok and also it (varies from) school to school. Some schools require you to do extra worksheets. I mean you don't have time to do experiments, you have to complete your workbooks; you got to do extra worksheets. Where do you find the time?(There are) only 2 hours (per week) and you got to complete quite a number of things.

She then moved on to another problem. Even though Isabella was a disciplinarian in the classroom, she still felt that she was incompetent. She was constantly soliciting confirmation from her students if they had acquired knowledge that day.

> I can get them to do experiments because I am quite a disciplinarian in my teaching style and so I make sure they will sit down and do their work you know that kind of thing. But of course, sometimes, there's a nagging thought at the back of my mind: have they learnt something? Sometimes I ask students (if they) learn something today to assure me (and not) them whether they have learnt something.

Isabella also seemed to subscribe to the notion that female teachers could teach language better than the male teachers.

> As a female make up, we are not so technical maybe? You know females are more linguistically inclined. I think it's quite true; they have done research that girls actually acquire language faster than boys and just making a general statement, I think boys are generally better in maths, the majority of the boys.

Isabella also saw a difference between male and female teachers where Science is concerned as she explained:

> Perhaps because I find that boys or men tend to be more knowledge seeking. Because many of the males I know like to read up encyclopaedia for some weird reasons but girls are not like that. Girls are not made like that to go and read up on like encyclopaedia. There are but it's in the minority, so perhaps a male

> teacher would be more equipped in terms of knowledge. Of course the teaching style varies again.

She agreed that an interest in Science also played an important part in whether someone liked the subject or not. For her, since she was young it had been a subject she deemed nice to know but not dying to know kind of thing. I moved on to asking her if she thought if male or female can teach Science better. She answered:

> They each have their own good point. If I were to say that all females are good in teaching language, that is not true because I have friends who are able to teach mathematics very well but they can't teach English very well. Similarly, there are male teachers who can teach English very well but not Maths or vice versa. It really depends very much on their interest.

Isabella also held negativities towards Science and was very pragmatic about it. When I asked her about her thought on Science in Singapore, she answered:

> It really depends on which field you are going into. If you are going to be a chemist or working in a pharmaceutical company, then maybe science will come in handy. But if not, then what are you going to do about it? I mean talking in the local context, Singapore, we are all very practical people. Whatever you need to succeed in life, it will be good that you learn it. But for those who don't need, then what is the point in doing it? It would be a waste of time.

4.7.1.2.8 END OF INTERVIEW

The duration for the interview was appropriate. Isabella was relaxed, chatty, friendly and informative throughout the whole interview. As such I gained tremendous information on the attitude and behavior of a low efficacy Science teacher. When I asked her for the possibility of calling her again should there be any doubt on my part, she was quick to accept my request.

4.7.2 INTERVIEW WITH TEACHERS OF HIGH SCIENCE SELF-EFFICACY

4.7.2.1 KRISTY FH3

4.7.2.1.1 BACKGROUND OF INTERVIEWEE

Kristy is a 28 year-old Science teacher from a school in the centre of Singapore. She has a Bachelor's Degree with a major in Biology from the National Institute of Education. She also holds a Biotechnology Diploma from a local polytechnic. She took up combined Science (Chemistry and Physics) in secondary school, and has less than 5 years of teaching experience and 3 years of teaching Science. She is the Science subject / level representative in her school.

Amongst all the teachers, her STEBI-A PSTE subscale score is the second highest in this research. Her STEBI-A STOE score was 47, and it was the second highest as well. The interview took place in a pavilion near her apartment. Kristy was very forthcoming in this interview and she answered every question in detail. In fact, she provided more relevant information than I had hoped for. As such the interview lasted for approximately 1.5 hours.

4.7.2.1.2 SCIENCE BACKGROUND

The interview began with the question as to whether she could recall anything pertaining to Science when she was in primary school. She replied that she could not recall any particular Science lesson or teacher. She failed Mathematics and Science when she was a young girl in primary school.

She did not receive any support from her parents in terms of education as they were busy with work. In secondary school, she was more interested in "fun subjects" like English, Literature and Home Economics and she excelled in them. In fact she hated Science. She could remember that in secondary one she did General Science. Up to secondary three she still found Combined Science "boring".

Home Economics was her Science back then because during Home Economics they had to learn certain processes, like why bread would actually get puffed up when yeast is added to it. Nevertheless, then she did not actually know that was Science.

To her that was Home Economics. When she was in polytechnic, she got to learn that what she had learnt previously was actually Life Sciences. In this way certain things began to get connected and she could make more sense out of those things that she had already learnt. She started to have an interest in Science.

4.7.2.1.3 WHAT / WHO INSPIRED HER TO BECOMING AN EXCELLENT SCIENCE TEACHER?

In year 2 close to year 3 in polytechnic, she had a female lecturer who was very passionate about her teaching. She knew her content very well and when she started teaching about certain concepts, she would just go on and on. This particular teacher inspired her tremendously. Kristy understood this teacher as the lessons were like following a story. It made sense to her, she started writing notes and finally a lot of things made sense to her for that module. She was interested in what she was talking about and as such she did well for that module. Thought she did not score a distinction, for her to score a "B" for a module was a big change.

Kristy realised that she was interested in some elements of that course after all. She claimed that if anyone were to ask her certain concepts that she had to recall, she was fast to say that that the few modules that lecturer taught "really stayed with her". This lecturer did not inspire her in terms of her later teaching career but it changed her attitude in learning and in picking up new things. She realised that since this lecturer made the effort to teach well, then she thought that it should be good manners on her part to listen, too. There were a few other lecturers who were like her as well. They were not as passionate as her, but because they tried to help her understand what was going on, she would try listening. If she did not know certain things she would go to them. If they tried to explain certain things to her, she would try to make an effort to understand what was going on.

Next I asked her for the reason why she had signed up with the National Parks. She could not provide any reason but said that she did not mind working with "plants", "farms" or on St. John's Island (an island with natural shores that have some of the most exquisite corals and other reef life). Kristy was asked to major in primary

Science when she applied to NIE. Although she failed Science when she was young, she had overcome this fear by going back to teaching the subject again.

4.7.2.1.4 ROLE MODEL AT THE NATIONAL INSTITUTE OF EDUCATION

One particularly good lecturer in the National Institute of Education that she could recall was a male lecturer. Before she graduated, she attended one of his modules on pedagogy, like how to teach primary Science, certain topics, etc. This particular NIE lecturer was very not only an approachable man but also a humorous man who always had something up his sleeve that made his lessons interesting. Kristy remembered one of the lessons; he had demonstrated a trick, but told the teachers that it was not magic but Science.

That left a deep impression on her as she used the same methods on her students to get their attention and found that those methods worked very well on her students too. In addition he had very interesting tools to share with the pre-service teachers, and very interesting setups and gadgets that could be used to teach the concepts from the primary school textbooks.

That motivated her a lot as she had never known that those tools could be used in teaching. She quoted an example; they were all given butterflies and caterpillars stored in a container. They brought them home to watch the metamorphosis take place. It was a very simple but it exposed her to this method of teaching. Science could be taught in this new way and it was not what was used, but the idea that it did not always have to be what is in your textbook.

As well as what is in the Science lab, there are other simple things that he or she can use as well. So from then on, whenever she was in school, she was always improvising. Because her ex-school did not have a lab technician back then, whatever things she could obtain would just be used to teach.

4.7.2.1.5 OUTDOOR PERSONALITY

Kristy also claimed that though she is a "girl", she did not mind going outdoors to "catch snails and digging into soil and catch earthworms". She explained her reason:

> [The] whole idea of teaching is that it can happen anytime anywhere. You can teach a child anything you want; science is more than just books and worksheets. I can bring them to a farm and I can teach them a lot of things. It does not need to be just science; it can be values, it can be English, it can be mathematics, it can be so much more. So, why confine myself to just a classroom and being a classroom teacher!

4.7.2.1.6 INTEREST FOR SCIENCE BOOKS

Kristy's passion for Science is very evident in her extensive reading. In the 1st year of service she had to read up more on Science on the internet and in books. She would go to the library and borrow books on experiments. In her NIE days she would go to book fairs and had bought a lot of books on Science experiments and during her holidays in NIE days, she moonlighted for a Science camp, where there were more resources. From that, she could just talk non-stop about certain topics to her students. As such textbooks became redundant. She confessed that she seldom used textbooks:

> Because it's (the textbook) paper to me. It's dead. I always tell the children science has to be done, it cannot be just visual. It cannot be just looking at pictures and words and you understand certain things. So when I tell them things like that, I will also promise them to do experiments. A lot of times they would be bugging me for experiments, they keep me going. It cannot be just be books. But I have to follow the guidelines as well, so the minimum I will do with them is books… Content must always be covered.

The following statement she made also showed her enthusiasm:

> I cannot just be doing paper work, chalkboard work… It has to be something more. So during my first year of teaching, I drained myself. I was constantly thinking of teaching ideas. I would be thinking, ok tomorrow I can do this… I was always preparing lesson materials.

For experiments in the practical book (scheme of work stipulated by MOE), Kristy was not afraid to change the experiment into something that would deliver the same outcome. She learned those experiments from the Science books she read. The aim was to allow the pupils to do and explore more. She would also conduct certain ideas or experiments on her own first. If they were successful with her class, she would propose them to her HOD and share them with the other classes.

4.7.2.1.7 ENTHUSIASM OF STUDENTS

I was very curious where Kristy had got the energy or inspiration to push on despite the weariness. She said that the students had played an important role:

> The main thing that drove me to all these things was the eagerness from the children; they were very (inquisitive) … So when (the students) want to learn more, I think it's my job to impart what they want to know and after that it became more of a partnership when I teach primary 5 and 6 children. They can work independently and I like how I can pass an idea to them, they just take it from there and do it into something that belongs to them; they own it. So I like that idea.

4.7.2.1.8 SUPPORTIVE HOD

Besides the students, Kristy's Science HOD who was also her mentor had guided her well throughout her tenure; she explained:

> She is very patient. She is very encouraging. She guided me along. It's not the content knowledge that she taught me. It's the way to do certain things… like if I want to run certain experiment in the school, she would (say) that Kristy you can't do this because parents (and principal)might not like it. So she is more of a mentor. Luckily for me, most of the experiments actually went through. I was able to conduct them.

4.7.2.1.9 BARRIERS FACED IN SCHOOL

Kristy had plans to run a composting project in school and wrote a proposal of exposing lower primary (primary 1 and 2) pupils to Science to get them ready for Primary 3 when they first get to do Science. She planned out lessons and activities, sourced and prepared for all the necessary things. Although she liked the ideas, it was not the same with the Principal. The Principal's lack of interest in her proposal in one way or another affected Kristy's enthusiasm in Science teaching. She ceased submitting major Science projects that required the Principal's approval. She continued with proposing minor projects and doing small classroom based activities, but the disinterested attitude of the Principal in her project proposals affected her after that.

The year before Kristy left her former school, a new Vice Principal who was formerly a Science HOD came onboard. The arrival of this man was rather important to her as just before he came she was no longer motivated to try out new things when she was into her second year of teaching. The new Vice Principal was very motivated to help improve the Science results, and spoke to teachers in the Science department about his ideas and plans. Kristy thought that he was a very supportive, passionate teacher when it came to Science. As a result, it rubbed off onto her, and that got her very interested again to try out even more new things.

We then moved on to more obstacles that Kristy faced while teaching Science. Just like Candice and Isabella, she faced the problem of limited time in preparing for experiments and teaching. She explained her frustration:

> [L]ike in most schools, it's the resources. (In my school), we don't have enough teachers so like for myself, I would have to take 3 science classes. It's taxing in a way that whenever I need to do lab work, or whenever I need to get the student to do things, most of the time, it's on my own or I'll buy (for sharing). It's all grab and go on a daily basis, it's not packed nicely for us. But a lot of times in a neighbourhood school, whatever we can get, we just hold on to them. And sometimes, you don't know who is holding on to it. So a lot of times, you don't know where the resources have gone to. This teacher might be holding on to 10 torches and we don't know who the teacher is. He or she didn't mean to do it but it's just that there's nobody helping us to do all these things. Certain schools could afford a lab technician who would set up everything for the teacher. We bring the class there, we run the experiment... Most schools will delicate 5 periods (for Science lesson). My former school was 5 periods. To me, 5 periods are enough to cover the syllabus, but not enough for the kids to have the chance to explore the subject well.

Next I asked if she had time to conduct the experiments knowing that they would probably take up substantial time. Because of that, she would use time allocated for other subjects for teaching Science. She elaborated:

> If you go according to the content, the syllabus, it should be enough. But a lot of times, we don't do that (go according to the timetable). So when it comes to timetable planning, my HOD would plan in such a way that I would teach the

> core and non-core (subjects) together. I would tell the children, I am your science, art, music and PE teacher.

4.7.2.1.10 RECOMMEDATION TO RAISE SELF-EFFICACY OF FEMALE SCIENCE TEACHERS

Just before we ended the interview, I asked for her recommendation as to what NIE could do to better prepare the Science teachers and she advised:

> [NIE focuses] mainly on research that has been done by people that we can try out in school and all that. They are good in exposing us to all these but I don't find them practical. All these things have been published and all that but I don't seem to be able to apply them in the classrooms. Instead they have to get teachers more familiarised with the content knowledge. If they are confident and comfortable to teach something that they know very well, then there would be more science teachers around.

She further gave suggestion on how to improve the content knowledge of the teachers through more hands on methods.

> For this module, we are given assignments all the time. You do an assignment and then you pick the level and the topic you want to do. And that's it. Then you get to see different people doing different topic of all that. We do get to see it, but you see the thing is, we only learn when we do certain things ourselves. So if I am teaching circulatory system or if I'm doing a project on the circulatory system, I would be the expert on this topic. But if I'm not doing other topic, I don't think by you sharing with me, I would learn that much. That's how I see it.

4.7.2.1.11 END OF INTERVIEW

At the end of the interview, Kristy disclosed that she had recently transferred to another school and just one month before the interview she had tendered her resignation letter to the school she was transferred to. Although she did not specify her reasons, she disclosed tersely that she was disillusioned with the demand and direction of the school. She did not wish to disclose if it was due to anything pertaining to her Science teaching.

4.7.2.2 SHERRY FH5

4.7.2.2.1 BACKGROUND OF INTERVIEWEE

Sheryl is a 29 year-old teacher who had been teaching in a school in the central of Singapore. She has a Bachelor's Degree with a major in English Language and a minor in Biology from the National Institute of Education.

She took up Chemistry and Biology in A-levels and Biology, Chemistry & Physics in O-levels. She had three years of experience in teaching Science. She was a regular teacher in the school. Amongst all the female teachers, her STEBI-A PSTE subscale score (55) is in sixth place, while her STOE (40) is at twenty-fifth. At her request, the interview took place at a café in a shopping mall near her house. The interview lasted for about an hour.

I asked her about her choice of putting English first instead of Science as the subject that she had the most confidence to teach. She replied that she had taught the language at all levels and it was a language that she used all the time. For placing Science second, she cited that the reason was that she only had three years of experience in teaching Science.

4.7.2.2.2 SCIENCE BACKGROUND

Sherry could not recall anything pertaining to Science from her primary school days as most of it was still "very text-book based" and the experiments were not inspiring. She looked rather excited when she spoke about her love for Science when she was a little girl.

> I like science. I always told my mom I like science mainly because I was reading a lot of magazines [about] zoo, animals, encyclopaedia and astrology. I did my own experience [like] catching insects and putting them under the magnifying glass. [I] will be walking along the road and looking out for interesting plants that grow out of nowhere. There are flowers, grasses or wheat I may find. They are quite fascinating to me, for example four leaves clover. I will purposely look for clover with four leaves or anything like that. If I see a plant that I do not know, I will look them up in guide book.

4.7.2.2.3 SUPPORTIVE PARENTS

Although Sherry did not have any particular inspiring figure when she was in primary school, her parents were always there to nurture her interest:

> My parents supported me by if I wanted any science guide books or magazines, they will gladly pay for the subscription. So they give me a lot of resources for me to find out on my own.

4.7.2.2.4 ROLE MODEL IN SECONDARY SCHOOL

When Sherry went to secondary school, the first and second years were pretty much the same as primary; there was not any special teacher or particular person who inspired her tremendously. In secondary 3 and 4, she took up biology and she met this "interesting teacher":

> There was this female teacher [who] was totally funny and then she put across a look to us. [It was] like [hitting] the right button to make us laugh and pay attention to her. For example, there was this topic on reproductive system which she actually didn't want us to read from the textbook. In fact for the 2 years, that textbook was hardly used. She would prepare her own notes for us and we were supposed to listen and note down the important [things] … for this reproductive [topic], she actually bound the whole book on male and female reproductive system. The cover was all yellow and when the class received this, we all laughed because in Chinese we say "huangshu" [which] means pornography. So everyone was carrying a 'yellow book' for the whole semester!
>
> She is very dynamic in the science classroom you will never feel that her energy is down. When she comes in, you can feel the energy is high; you have to match your energy level to her. It made you pay attention to her lesson more. When I was doing O level, dissection was already out of syllabus, but she thought she was going to let us have some experiences. She actually brought a rabbit and we dissected the rabbit in the lab. If not for her, we probably do not have this experience. It was very enlightening because if you just read things from books or see pictures, [it] is never 3 dimensional. But when you do a real dissection by yourself, you can see a rabbit's organs, the heart beating, the intestine and everything.

Sherry's teachers in secondary school played an important role in her Science. Although there was the abovementioned teacher who inspired her, another, a male teacher, actually de-moralised her:

> [The] physic teacher was really the guy that turned a lot of us off because he was killing us with his killer questions. So I totally hated that.

4.7.2.2.5 CLASSROOM BEHAVIOUR

For her lessons, Sherry confessed that she turned to the textbooks and guide that is the bulk of the information and syllabus comes from. She brought in samples to attract the students' attention:

> When I am teaching science, I would tend to bring (items like plant) to pipe their interest. There was this one time when I brought in this huge plant. [The children] were all quite excited, wondering what kind of plant it was. For animal, I would [go to websites to] show the kids animal or something like that.

There was even one day when she saw a caterpillar while walking towards school. She believed that Science was not just about books and classroom, and brought the whole class to the spot where she had seen the caterpillar.

4.7.2.2.6 BARRIERS FACED IN THE CLASSROOM

Like many other teachers, Sherry also faced the problem of limited time for teaching. Fortunately she taught the class English, Mathematics and Science, and she had 'stolen' time meant for other subjects to teach Science. She divulged that this had been a common practice among teachers.

4.7.2.2.7 ENTHUSASM DISPLAYED BY SHERRY

Sherry proposed that Science should be fun and interesting so that students would see that Science is part of their daily lives and continue life-long learning of the subject. It should not stop when they leave school. The curriculum should include more emphasis on hands-on activity and projects for self-learning. All these require more time allocated. In addition, pen-and-paper tests should be revamped to show more emphasis on the hands-on aspect of assessment. Her statement reflects well that she is not a text-book based kind of teacher - she was always prepared to get her hands dirty to demonstrate what Science is all about.

Just before the interview ended, Sherry shared with me that she had not been teaching Science for some time already since she was teaching primaries one and two and foresaw that she would not be doing so in the next two years. But that did not stop her from incorporating Science into her current teaching.

> I would use my own initiative to incorporate science into my lesson. For example [in] P1, we read story books and we learn English from there, and there was a couple of story books where we were learning about fruits and plants. We actually brought the kids to the science centre to learn about seed dispersal. [The children] see real fruits on the trees or grapes on the vine, or rice growing from the plants. It helps to stimulate their interest from early age for things related to science and nature. They can see that whatever they learn in books, can be related to things around them; it's not just restricted to their books alone.

For example she was very enthusiastic about Big Books (blown-up books). She saw value in such story books. From those books, they learn English through the life cycle, weather, fruits and animals, etc. Her colleagues who were as enthusiastic as her chose non-fiction books that could be linked back to Science. She found that she could link English words "tall" and "short" using giraffes. She looked forward to giving the pupils the Science "exposure" when their plans materialized.

4.7.2.2.8 END OF INTERVIEWS

After the transcription which took weeks, and analysis and interpretation of the interviews, a copy of the transcript was sent to the respective interviewees. This not only minimises bias but also ensured what was to be reported was all accurate and that I have not imposed my opinions on them.

4.8 SUMMARY OF THE FOUR INTERVIEWS

4.8.1 Female Science Teachers with Low Science-Self-efficacy

From the interviews with the two low self-efficacy female teachers, I summarise their responses as below:

- Both teachers did not have role models when they were still students in primary school. They could not recall any teacher who had inspired them in any way in primary school. In fact Isabella did not have any inkling at all of her primary Science lessons. Candice liked Chemistry in secondary school because she found it interesting but could not give any reason for it. Isabella attributed her "good" results in Chemistry in secondary school and her liking for Chemistry to her Chemistry teacher who was deemed "motherly'. They did not take up Biology in secondary school which made up a substantial portion of the primary school syllabus. They agreed that Chemistry was "more fun" than Physics. In their overview of the primary Science syllabus, the ministry has mainly incorporated the two major fields of Science, namely Life Sciences and Physics in the new syllabus. The above two fields in fact were not favoured by the two teachers involved. Isabella and Candice had revealed that they preferred Chemistry over Physics and Biology. Outside of the school, there were no other people (sibling, parents, relatives, friends, etc.) who had inspired them too.

- Teacher Candice was forced to take up a Science course in college for elective as it was compulsory to do so. She claimed that she would not have taken up any Science-related courses if it was not compulsory.

- Both teachers felt that the National Institute Education had not prepared them well enough in terms of Science content and pedagogical knowledge so as to be a good Science teacher. In their schools, they did not have the right mentor to guide them. The mentor of Isabella had limited knowledge in Science and as such, the former could not approach her when she faced any problem in teaching Science.

- Both teachers faced limited time in imparting knowledge and lesson preparation, deficiency in Science content knowledge, limited Science facilities and absence of a laboratory assistant to help prepare for Science experiments. They did not display any confidence while conducting Science experiments.

- Isabella was constantly asking her pupils if they understood her Science teaching to assure herself that they had really learnt. Both teachers felt very apprehensive if they were to teach Science again in the near future. Throughout the two interviews, the two teachers spoke only of negativity with Science.

4.8.2 Female Science Teachers with High Science-Self-efficacy

From the interviews with the two highest self-efficacy female teachers, I summarised their responses as below:

- Both teachers loved nature and had personal interest in teaching science. They were always ready to explore plants and animals. Sherry had been always curious about plants and animals from a young age. She might not like handling insects but that did not stop her from exploring more about them. She sought help from her mother who was always ready to help when she was young when she wanted to "catch" and examine certain animals. She read up a lot on Science-related books. Kristy loved the outdoors activities and was ever-ready to get her hands dirty. Likewise, she read up a lot about Science and experiments from external sources and did not rely on textbooks. She was also ready to modify experiments in the school's Science practical books so that her pupils would have a chance to learn and explore more.

- Both teachers' passion for teaching Science was sparked off by someone in their lives. Kristy was very inspired by a female lecturer in her polytechnic days and another male lecturer in her NIE days. The knowledge that the female lecturer possessed, her enthusiasm while teaching and the tricks that she learned from the male lecturer to make Science lessons more interesting for the pupils inspired her to work hard and eventually to like what she was doing. Sherry's parents were supportive as they would always buy her any Science-related items she liked. Just like Kristy, Sherry had a "dynamic" Biology teacher whose lessons were always interesting. This teacher showed her that Science does not have to be all about the textbook; she used live objects like a rabbit to show the class instead of a 2-dimensional picture on the book.

- Kristy had the right mentors in their schools to guide her. She attributed her success particularly to her Science HOD, a lady, and a new male Vice-Principal. Her principal was mostly unsupportive of her proposals for Science programmes. The former would either reject them, or worse, did not come to her at all. That affected her tremendously but the HOD and the new Vice-Principal were there to give support. The latter listened to her proposals carefully and always displayed enthusiasm. She saw the relationship of the students and her like a partnership. Although Sherry did not have a mentor, she credited her success to her experienced fellow colleagues who gave her all the support along the way. They shared the same idea that Science did not have to be taught as a standalone subject, but it could be taught together with English and Mathematics.

- Throughout the two interviews the two teachers displayed enthusiasm and were most forthcoming about their Science teaching. Many times, both teachers would initiate other topics pertaining to their Science teaching even before I could prompt them.

- Content Knowledge was never an issue as they did a lot of reading pertaining to Science. They would turn to books and the internet to learn more about the topics they were going to teach.

- Both teachers pointed out their barriers, i.e. limited time for Science teaching, limited equipment, and the absence of a laboratory assistant to prepare for Science experiments.

4.9 CHAPTER SUMMARY

In this chapter I reported the results of the STEBI-A and teachers' responses to my survey questions. The four interviews with teachers of low and high self-efficacy are presented. From those interviews I gained a better understanding of their prior experiences and academic background. I also learned more about the teachers' personal interest in Science and if anyone had influenced them along the way. The teachers also disclosed their classroom behaviours and their primary concerns about the teaching of Science in the school.

CHAPTER 5

DISCUSSION & SUMMARY OF RESEARCH FINIDNGS

5.1 INTRODUCTION

In this chapter, the interviews with the four teachers who gave vivid accounts of their experiences as science teachers are discussed. This is followed by the discussion of the results of the STEBI-A, and the responses of teachers to those questions posed in the survey. The interviews and their responses to the survey revealed enablers and obstacles they faced as female science teachers in Singapore. After the discussion and summary, recommendations are made to raise the science self-efficacy and optimise science teaching for female teachers in Singapore through Bandura's four principal sources of self-efficacy beliefs (enactive mastery, vicarious experiences, verbal persuasions and physiological / affective states).

5.2 DISCUSSION OF INTERVIEW

5.2.1 Teacher with low Science self-efficacy

In the '8 Dimensions on High from the Low Efficacy Teachers', a point that Ashton (1984) stated is 'Personal Responsibility for Student Learning' – teachers with a high sense of efficacy believe that it is their responsibility to see that children learn and when their students experience failure, they examine their own performance for ways in which they might have been more helpful. However, those teachers with a low sense of efficacy shift the responsibility for learning onto their students. Isabella evidently displayed the latter's point; she believed that the students already held certain knowledge about the Science they should know. She believed her job in the Science classroom was not a teacher but more like a facilitator.

Similarly Candice did not claim any credit for any success story of her students in her Science class, and attributed the success of her students to their own effort and the parents' contribution.

Teachers with low self-efficacy also use an authoritarian approach in their teaching (Bandura, 1997), that was much evident in Isabella's behaviour in the classroom. Although Isabella said that though she was effective in monitoring experiments, she admitted that she was only able to get her pupils to complete those tasks using the authoritarian approach. She made sure the students would sit down and do their work, but there was always nagging thoughts at the back of her mind wondering if the students had learnt anything from the Science experiment.

Sometimes Isabella had to ask her students if they had learned something that day to assure herself that they had indeed learnt something. Such reflection has also been pointed out by Ashton (1984) of Positive Affect that teachers with low sense of efficacy are frustrated with teaching and frequently express discouragement and negative feelings about their work with students.

One of the factors that Paige (1994) pointed that contributed to the female teachers' expertise in teaching primary science is influence and support from key people. In Candice and Isabella's cases, both of them did not cite anyone in their current school such as (teachers, focus teachers and coordinators) that had inspired them to be better science teachers. Mentorship was almost absent in their schools. If a mentor lacks mentoring skills, problems may surface in mentoring relationship (Soutter et al., 2000, as cited in Hudson, 2004). Hudson (2004) advised that mentors need to possess pedagogical knowledge of primary science for guiding the mentee, but if the mentor's pedagogical knowledge of primary science teaching falls below a mentee's knowledge, then the mentor's credibility and suitability may come into question. Unfortunately the above predicament was exactly what the two female faced while teaching science. Isabella claimed that her mentor was not a "Science person" and as such had limited science knowledge. She admitted that she would not approach her for any advice should she encounter any obstacles pertaining to science. Both teachers claimed that they had to depend very much on themselves to carry out any science preparation works or classroom teaching.

Boo (2006, 2007), as mentioned on page 21, found that misconceptions of question setters or teachers and the concepts involved in the test item are a recurrent source of problems to many question setters. Teachers can be the source of many of the misconceptions held by students, and such erroneous items are also likely to perpetuate the students' misconceptions which are resistant to change or, worse, introduce misconceptions where formerly correct conceptions were held (Boo, 2007). Those students would then become future teachers and the misconceptions amongst students and teachers would continue. This problem could also be a vicious cycle for the science teachers who relied heavily on past year exam papers to set examination questions.

Candice admitted that she faced problems while setting examination papers, which was largely due to her limited science content knowledge. The only way to circumvent her problem was to refer to past year examination papers from other schools and modify the questions. For her science lessons, she admitted she either read from the textbooks directly or used PowerPoint to present the information which came normally from the textbook.

Such practices are characteristic of Science teachers with a negative attitude and low confidence in the teaching of Science as reported in the study of Glynn et al. (1991) who stated that school Science curricula are mainly "textbook-centred". Candice's score on the STOE subscale was the lowest amongst the female teachers and it is a known fact that scores on STOE subscale have also been related to the quality of teaching in Science.

The multiple barriers cited by the two teachers were easily resolved – they simply requested the school not to allocate any Science classes for them to teach. Isabella appealed to teach physical education while Candice requested for English and Mathematics. This finding is consistent with Stefanich and Kelsey's (1989) that teachers have been avoiding teaching Science in the elementary school curriculum and that they prefer teaching other subjects in preference to Science.

5.2.2 Teacher with High Science self-efficacy

Both Kristy and Sherry appreciated nature and the outdoors since they were children. Similar findings were also found by Paige (1994) who reported it as one of the factors teachers stated that contributed most significantly to their expertise in primary Science education.

Unlike Candice and to a certain extend for Isabella, who did not really have any role-model when they were younger, Kristy and Sherry mentioned teachers who had influenced them in one way or the other. For example, in her secondary school, Sherry's biology teacher was inspirational. The latter was dynamic, humorous and as such Sherry paid close attention to her lectures. This teacher did not use textbooks at all, but she prepared her own notes for the students. The lesson on dissection left a deep impression on Sherry although it happened more than fifteen years ago. Sherry was very appreciative of the teacher's effort because dissection was no longer in the syllabus but she still wanted the students to look at animal organs in 3 dimensional. The recollections of positive, enjoyable Science-related antecedent experiences from which they developed a lasting interest in Science have been cited by Ramey-Gassert (1994), as one of the factors that contributed to high science teaching self-efficacy beliefs.

Role models also played an instrumental role in enhancing Kristy's self-efficacy. According to Bandura (1977), the more closely the observer identifies with the model, the stronger will be the impact on efficacy, especially when a model the observer identifies performs well. The humorous and approachable NIE lecturer Kristy had inspired her so much that she made use of similar methods (interesting tools, setups and gadgets) taught by him to teach concepts to her students and they worked very well. As Kristy began in-service teaching she began to explore even better methods to teach science. This also substantiated the finding that experienced teachers will affect the professional future of new teachers since the latter use pedagogical methods that are very similar to those they preferred in their own teachers when they were students (Huibregtse, et al., 1994) or teach in the same way they themselves were taught (Tobin, et al., 1994).

Kristy's willingness to try a variety of materials and approaches, the desire to find better ways of teaching, and implementation of progressive and innovative methods parallels Allinder's (1994) report of teachers with high teaching efficacy. Her dedication towards her science teaching and the additional time she spent on the subject have also been pointed out by Bandura (1997) and Riggs and Jesunathadas (1993) respectively of teachers with high self-efficacy.

As mentioned before, scores on the STEBI STOE subscale have also been related to the quality of teaching in Science. Kristy's high score in the STOE subscale (second in this research) is an evident that she believed effective teaching of science will benefit the students. She was one typical high efficacious teacher who tried harder and used management strategies that stimulate student autonomy as mentioned by Ross (1998). She thought that her job as a science teacher was to impart what her students wanted to know. And after that it became more of a partnership (another positive point mentioned by Ashton, 1984) and the students would then work independently.

Kristy also refrained from using those "very useful" teachers' handbooks prepared by the publishers which prescribe precisely how a concept should be taught (So, Tang & Ng, 2000). She used knowledge gained from other literature to teach her students.

Highly efficacious teachers are also more likely to be effective in their classrooms by displaying enthusiasm for teaching (Chen, 2006). Kristy's enthusiasm was shown in her statement that she did not believe in just paper and chalkboard work. To her, Science lessons had to be something more. She tried very hard and was constantly thinking of innovative teaching methods and preparing lesson materials.

It is easier to sustain a sense of efficacy when struggling with difficulties, if significant others express faith in one's capabilities than if they convey doubts (Bandura, 1997). Persuasory efficacy attributions have the greatest impact on people (such as Kristy) who had some reason to believe that they could produce effects through their actions (Chambliss & Murray, 1979a, 1979b). Hence to raise self-efficacy through verbal persuasion, encouragement in-depth informative feedback from the learner's mentor is important. Isabella and Candice claimed that their mentors had been unhelpful; the former's mentor was unknowledgeable in science, while the latter's very much left her alone to explore the subject on her own (e.g. setting the examination paper alone). On the other hand, Kristy's Science HOD had regularly given her positive feedback on her performance. In the interview, she attributed much of her success to her mentor who provided her with a listening ear, gave her support and approved many of her Science-related proposals. The nonchalant attitude of her principal who had affected her significantly also illustrated the importance of positive feedback from higher school administrator.

As for Sherry, although she was given only English and Mathematics to teach (there is no Science in primary one and two), she did not forget about the science subject that she loved since she was a child. She was constantly looking for ways to incorporate science into her English curriculum.

Highly self-efficacious teachers believed that they could reach their low-achieving students and overcome the problems of students. They saw it as their responsibility to help these students overcome their problems and took pride in their ability to teach these students (Schriver & Czerniak, 1999). Those attributes were evident in Sherry who encountered many "problematic" students. She did not simply ignore them but instead tried whatever way she could to assist them.

To see children enjoying, discovering and learning in science contributed to female teachers' expertise in teaching primary science (Paige, 1994). Kristy's students played a crucial role in spurring her on. They were always inquisitive during her science lessons and wanted her to teach them more. She confessed that she was exhausted at times, but seeing the enthusiasm of her students, she was rejuvenated.

Self-efficacy beliefs can be affected by physiological and affective states such as stress and anxiety. Kristy and Sherry's physiological and affective states were on the positive side as they had a group of very supportive colleagues (vice-principal, HOD and fellow teachers) who were always ready to assist. Influence and support from key people contribute to female teachers' expertise in teaching primary Science (Paige, 1994). Whenever the two teachers encountered any obstacles in teaching Science, they would approach more experienced colleagues or colleagues for assistance.

5.3 DISCUSSION OF RESEARCH FINDINGS (STEBI-A)

5.3.1 Personal Science Teaching Efficacy & Science Teaching Outcome Expectancy

In the beginning of this thesis it was hypothesised that the PSTE of the female primary Science teachers in Singapore would be lower than their male counterpart. On pages 94 and 96, the results of independent t-tests show that there is no difference between mean score of males and females for STOE but are different for PSTE, i.e. male teachers have higher PSTE. But after multiple t-tests corrections, the results are marginal insignificance ($p=0.031$ compared to $p=0.025$) for mean PSTE scores between gender. The correction was a very useful technique and it is hoped that the explanations capture how equivocal the results are. It is believed that the trend is probably reflective of a phenomenon (i.e. male teachers have higher PSTE than their female counterpart) but naturally the data does not support this claim. So it is necessary to find out what had caused the differences in their level of self-efficacy.

Riggs (1991) offered the reason of the different experiences males and females can encounter within the same classroom. It is known that both the quality and quantity of classroom interactions are inequitable, with male students typically receiving more specific feedback from the teacher, and the trend seems to follow female students from elementary years through college (Sadkers & Sadkers, 1986). It was proposed that the higher Science self-efficacy ratings of the males are due to the higher expectations put upon male teachers by those around them (Riggs, 1991). The male teachers are often thrust into the role of Science coordinator for the school, and as such could have led to a self-fulfilling prophecy in that the male teachers and end up viewing themselves as Science teaching experts (Riggs, 1991). Another researcher, Azar (2010) believed that the differences in the scores of different studies (whether males have higher or lower self-efficacy than their female counterparts) might just be a result of cultural differences.

Unlike the above point on PSTE, the finding on STOE is inconsistent with the hypothesis made in the beginning - that the STOE subscale score of the female primary Science teachers would be below their male counterparts. The mean score for the female teachers' Science Teaching Outcome Expectancy is 39.9, while the male teachers' Science Teaching Outcome Expectancy is 40.5. Although the mean score for the male teachers is higher than the female teachers, the difference is extremely small. This finding highlighted that the teachers, both male and female, believed that effective teaching of science, and not the gender of a teacher, would affect the outcome of teaching, and thus have benefits for their pupils.

5.3.2 DISCUSSION OF TEACHERS' RESPONSES TO SURVEY

- **5.3.2.1 Do you have the necessary/adequate training/education to teach Science?**

For the above question, only two thirds of the female teachers stated that they had the necessary training and education to teach primary Science. This is in stark contrast to the three quarters of the male teachers who stated that they had the necessary training and qualifications. As the number of teachers who had a Science diploma or degree is very small, it is impossible to conclude the reason(s) for the above finding. There is a possibility that the male teachers in this research underwent more workshops, courses, lessons, etc. in their own respective school. Again, this research is unable to answer this question as the questionnaire did not specify the number of workshops, courses, sharing sessions, etc. that they had gone through and especially the depth of each one of them. It would be difficult for the teachers to quantify the number of such professional development programmes they had undergone so far.

The above finding is nonetheless consistent with reports that content knowledge is one of the barriers female teachers faced in their Science teaching (e.g. Appleton & Kindt, 1999; Rice, 2005; Riggs, 1991). Several studies have shown that deficiencies in content knowledge could lead to many problems in the process of teaching and learning of Science (e.g. Newton & Newton, 2001; Abell & Roth, 1992; Grimellini & Pecori, 1988; Smith & Neale, 1991). Consequences as a result of this barrier were clearly illustrated in the interviews of Candice and Isabella. The finding also affirmed that Singapore female teachers still faced the perennial barrier of inadequacy in content/pedagogical knowledge since Chin et al. (1994) reported about it more than fifteen years ago. Suggestions to raise the science self-efficacy in terms of content/pedagogical knowledge of primary teachers will be discussed on page 149.

- **5.3.2.2 Did you receive anything (praise, feedback, etc) from anyone that made you believe you could teach Science well**

Only 4 female teachers out of the 80 teachers mentioned that either a colleague or colleagues and a supervisor (HOD, vice principal or principal) had praised or given them positive feedback that made them believe they could teach Science well.

This finding provides evidence that Singapore primary female teachers were receiving limited positive feedback about their science teaching performance in school. Kristy's comment on her two supervisors (one was very supportive, while the other was indifferent to her) illustrated the importance of praise and positive feedbacks for teachers.

On the contrary, female teachers, as well as male teachers in this research, were receiving more positive affirmation and feedback from their own science students.

Female teachers stated that the students achieving good results in examinations affirmed their beliefs that they could teach science well. Their beliefs were also affirmed when her students began to understand a concept that they could not previously understand although it had been taught to them by other teachers.

Another point the teachers raised was that the students understood science better under their coaching or the students told them that they liked their science lessons.

The teachers also got another affirmation when their pupils started questioning her beyond what she had taught them; this was an indication that she had triggered their drive to probe further. When they saw their pupils explaining certain Science concepts to classmates, it confirmed that they had been teaching Science so well that the students were able to inculcate the knowledge to their peers.

These findings substantiated the findings of Paige (1994) that the joy of children discovering and learning in science as a factor that contributed to the women's expertise in teaching primary science. Positive feedback from students will encourage teachers by enhancing perceptions of their ability to implement successful science teaching which is the key antecedent to a strong sense of science teaching self-efficacy (Laat & Watters, 1995).

On the other hand, this finding is disconcerting as only a meager number of female teachers reported that they received affirmation like praises and positive feedbacks from their supervisors / mentors about their science teaching. More on lack of mentorship and feedback is discussed on page 146.

- **5.3.2.3 How did / does the Science Department help you to raise your Science-teaching efficacy?**

Almost all of the female teachers (52 of them) mentioned that their schools organised Science courses, workshops and sharing sessions to raise their self-efficacy. Those activities have been recognised as sources of powerful influence on self-efficacy – they are done through mastery experience and vicarious learning (Bandura, 1997). Professional development is the most important factor influencing confidence primary science teaching (Murphy et al., 2007) and had a long-term effect on changing Science teachers' beliefs (Cripe, 2009).

The finding of this research provides further support and evidence that one of the enablers that female teachers believed that had raised their self-efficacy was through professional development programmes such as the science-related activities that the school provides. Training and development provide opportunities for female primary science teachers to explore different methodologies and then return to the classroom to trial them (Paige, 1994). Through professional development, when a model with whom the observer identifies performs well, the efficacy of the observer is enhanced (Bandura, 1977). In addition, sharing sessions raise self-efficacy of teachers. According to Gulla (2005), informally sharing teaching narratives is effective as it gives teachers access to strategies that are most suited to their particular needs. Often embedding practice in a story mirrors the very strategy the story describes.

- **5.3.2.4 Which is the subject that you consult your colleagues about most frequently?**

About half (27 teachers) of the female teachers in this survey indicated that Science was the subject on which they consulted their colleagues most frequently. They approached them for answers to questions from students, in worksheets, in examinations and on concepts in textbooks.

Some of them confessed that they were unfamiliar with the Science content and procedure for experiments. There were teachers who wanted to discover and understand how to bring across certain theories or explanations better to the students. Teachers also sought new, interesting methodology in teaching certain topics in science.

From the teachers' answers to the above question, we could conclude that Singapore primary teachers needed the most help in science amongst the three core subjects. The reason for the high frequency in consulting their fellow colleagues provides another strong evidence that one of the barriers that affected the self-efficacy of the Singapore female science teachers is their content/pedagogical knowledge. This finding also parallels Harlen and Holroyd's (1997) report that elementary school teachers needed help on how to teach science more effectively. Many science concepts are changing as it is a dynamic subject and that there are often ambiguities and quirks in the field of Science. This finding provides the basis that the most assistance should be given to female teachers teaching science be it in NIE or in school.

As for English, teachers indicated that they had difficulty in correcting pupils' errors in expression. The language is simply too wide, ambiguous and confusing. They consulted colleagues to gain more ideas about teaching that subject. Marking is also subjective. They needed clarification for alternative answers.

Mathematics was the subject that was least consulted. As explained it is a well-known fact that Asian teachers have expertise in Mathematical knowledge for teaching. Some teachers approached their colleagues for good teaching practices and ways and strategies to solve problem sums. They wanted to learn interesting activities to do with their students, and ways to get the students interested in the subject.

- **5.3.2.5 What are the major obstacles you face that stand in your way to optimum Science teaching?**

The major obstacle that stood in the teachers' way to optimum Science teaching is the limitation of time with more than half of the 80 teachers (29 females) mentioning it. Lack of content/pedagogical knowledge was once again mentioned by many teachers and ranked second while lack of Science resources/assistants was ranked third. A few teachers attributed their students' attitude and others as obstacles.

The limitation of resources/assistants and time in science instruction has been reported in many studies (e.g. Shrigley, 1977; Scott 1988 and 1989; Murphy et al. 2007; Lee et al, 2000). It was no surprise a large number of teachers mentioned time as the major obstacle for substantial time was needed to prepare and conduct science lessons such as outdoor activities, inquiry based activities and experiments. However the subject is/was given the least number of periods amongst the three core subjects in Singapore primary school.

Primary school teachers are known to have generally low level of knowledge (Stevens & Wenner, 1996; Wenner, 1993). And in Singapore, the teachers' lack of academic and pedagogical content knowledge (Chin et al., 1994) has been a recurrent issue. More on the above barriers will be reported on page 142 in the summary.

- **5.3.2.6 As a male/female, do you think a male teacher can teach science better than a female?**

Paige's (1994) pointed out that high perceived Science efficacy teachers reported a passion for the subject as the most important factor in their reported high Science efficacy. Almost all of the 53 female teachers asserted that they did not subscribe to gender stereotypes with regards to the academic inclinations of either sex. There were 13 female who quoted passion / interest as important factors that bring out a good Science teacher, regardless of his/her gender.

From their responses to the question, we have a good idea of how they felt about the issue. The female teachers strongly believed that teachers who were passionate about teaching the subject would do everything they could to help the pupils appreciate what they were learning. Be it a male or female, both genders could help a student achieve results in Science by his/her style of teaching and teaching ideas.

On the other hand, some male teachers found that they could teach Science better than the female teachers as they equated science to masculinity. Their reasons were that female Science teachers could not take on the role of men who are tougher, more willing to touch animals and get dirty outdoors.

The above result nevertheless confirms that Singapore female primary teachers strongly believed that both genders could be proficient Science teachers, and they considered passion, knowledge, effort, interest, etc. as the most important factors to becoming a good Science teacher. This could probably explain the small difference between the STOE subscale scores of the male and female teachers.

- **5.3.2.7 Who (if anybody) do the female teachers model themselves on as a Science teacher?**

About one third of the 53 female teachers mentioned that they modelled themselves on their HOD or their colleagues to be better Science teachers, and approximately half of the female teachers wrote that an ex-teacher/lecturer had inspired them. This finding is consistent with that of Paige (1994) that one of the contributing factors for women to develop expertise to teach primary Science is the influence of key people. She mentioned that those people could be focus teachers, coordinators, peers, teaching mates committed to science, lecturers at college/university and family. Seeing role model talk about their experiences has also been identified as one of factors that beliefs are often acquired through observation and interpretation, or hearing role models talk of their experiences (Bandura, 1986). This finding shows once again the importance of colleagues particularly their supervisors who are likely to be their mentor, who will assist the teachers in preparing, negotiating and enabling the mentee's teaching practices towards higher levels of teaching competencies (Zachary, 2002, as cited in Hudson, 2004).

- **5.3.2.8 What did / will you do when you encounter trouble or problem in teaching Science**

There were 65 teachers (42 female teachers) who mentioned that they would seek help from a colleague if they encountered any problem in teaching science. Other teachers mentioned “check the internet” or “read up books”. Although it is obvious that teachers are likely to seek help from those who are working closely with them or Science teachers who “should know” the content well, such thoughts could have drawbacks.

I had mentioned during the introductory chapter of this thesis that through his scrutinizing of a substantial number of primary Science examination papers, Boo (2006) warned that there were scores of misconceptions held by Singapore female Science teachers. Those science examination questions had undergone rigorous vetting processes usually led by the head of department and committee members. This finding again reaffirmed the fact that a strong acquirement of content knowledge of the female Science teachers is paramount. If this issue is not addressed, the vicious cycle will continue - the young female teacher will learn a particular Science misconception from a senior teacher, and then the former will pass on the misconception to future young female teachers.

Since teachers share lots of science information, then it is expected that more experienced teachers possess superior science knowledge. A low sense of efficacy can be contagious among a staff of teachers, creating a self-defeating and demoralizing cycle of failure (Bandura, 1997). If a female Science teacher were to consult another Science teacher about a subject that she did not know, the further reduction of self-efficacy for this subject will likely to take place. As such, as stated, both the mentor and mentee must undergo constant professional development programmes to develop their science self-efficacy.

- **5.3.2.9 Which subject, English, Mathematics or Science, is the female teachers' most confident and least confident subject to teach?**

Amongst the three subjects, female teachers ranked Mathematics as the one that they had the most confidence to teach. This was followed by Science and then English.

The same ranking went for the male teachers as well.

ENGLISH

A total of 43 teachers, 17 males and 26 females, ranked English as the least confident to teach, while 11 teachers, 4 males and 7 females, ranked English as the most confident to teach. Contrary to my hypothesis that English would be ranked by the female teachers as their most confident subject to teach, the language was placed the lowest not only by the female, but also by the male teachers.

Weiss et al. (2001) reported that the teachers in their studies ranked Reading as their most qualified subject to teach, Mathematics/Social Studies was ranked second while Science (Life and Physical Sciences) was third.

English is a language which is not the mother-tongue of most of the Singapore primary teachers. From their responses, we could gather that in general their aversion was largely due to their knowledge of the subject. Teachers' confusion between American and British English in teaching was mentioned in their response. According to them there are too many grammatical rules which are confusing, and too many illogical rules of processes to explain. The rules are always changing and there are variations of acceptable answers. There were too many components (Grammar, Vocabulary, Spelling, Comprehension, Compositions, Oral, etc.) which led to a heavy workload especially in marking (most classes had between 30 and 40 students). Another teacher found that it was a subject in which the foundation and background of the pupils was very important. It is also hard to see results from their students and it is difficult to quantify progress. One teacher believed that English could not be taught – it is language that is acquired over time as opposed to being explicitly taught. All a teacher can do is to correct their mistakes in most components. There are very few resources provided to make English lessons creative – it requires the preparation of a lot of work / resources. There are not enough hands-on activities as compared to Mathematics and Science. Teachers have to constantly think of new innovative ideas to make English lessons interesting. A teacher commented that when conducting English lessons, it was impossible for her to use manipulative unlike in Mathematics to arouse the interest of her students.

MATHEMATICS

Mathematics was ranked the highest by both the male and female teachers to be the one in which they had the most confidence to teach. 37 out of the 53 female teachers expressed that they had the most confidence in teaching Mathematics, while 17 out of the 27 male teachers said the same. It is a known fact that Asians excel in Mathematics. East Asian teachers and students possess very strong skills in Mathematics, and the teachers understood more deeply the fundamental of Mathematics (Siegler & Mu, 2008). As such it is no surprise that the teacher participants chose Mathematics as the one in which they felt the most confidence to teach. It is a more structured subject that does not change drastically over time. Most of the current teachers had learnt the same Mathematics concepts when they were in primary school, and as such were competent enough to inculcate the knowledge to their students.

Only 4 male teachers and 7 out of the 53 female teachers stated that Mathematics as their least confident to teach. Teachers who did not place Mathematics at the top position as their most confident to teach, quoted that Mathematics was not their forte. Some of them found it to be the most challenging of the three subjects, and found that it was hard to impart mathematical skills. A teacher disclosed that he/she especially had a lot of trouble conveying concepts effectively to upper level pupils especially challenging problems. She/he blamed it on the fact that she/he had not performed well in Mathematics during his/her student years. Another teacher expressed his hatred towards the "dry" subject and as such his students also hated it.

SCIENCE

Science was ranked second perhaps the teachers just felt that they encountered only certain surmountable limitations such as time to plan and conduct their Science lessons or limitation in resources. Other than that they still felt reasonably confident enough to teach the subject. Science could also be seen by the female teachers as a neutral subject because many teachers had placed English as the least confident, while Mathematics was overwhelmingly ranked as the most confident to teach.

For those teachers who ranked Science first as their least preferred subject to teach, once again, lack of content/pedagogical knowledge was brought up, with half of them citing it as the reason. They felt that Science topics are dynamic, abstract, very wide and varied and change over the years. It is a subject that requires them to undergo constant reviewing and updating to stay current. One teacher even feared giving wrong ideas and teaching the concepts to her pupils. Another wrote that Science concepts were not so easily explained, and she was not very sure about some of them too. Two teachers felt that some of the topics were too technical for the comprehension of the pupils. Because there were so many irregularities in answers, it was difficult to get the students to apply answering techniques. Teachers also complained that there was too much "tedious" and "troublesome" preparation works for Science experiments to bring concepts across.

Another teacher attributed it to the language skills of the students. She believed that if a student was proficient in English, then he/she would not have any problem in Science which would eventually lead to high Science scores. Incidentally, this is one of the attributes (i.e. taking no responsibility for the student's academic results) of teachers with low self-efficacy as reported by Ashton (1984) and Schriver and Czerniak (1999).

5.4 SUMMARY

5.4.1 ENABLERS & BARRIERS FACED BY FEMALE SCIENCE TEACHERS

This section summarises and discusses the enablers and barriers identified by Science teachers through the interviews and survey. The low self-efficacy of female teachers on the PSTE subscale as compared to their male counterparts could probably be explained by the barriers they faced in Science teaching. It is hoped that through enhancing the enablers and addressing the barriers, the science self-efficacy of the primary teachers particularly the female teachers would be raised.

Most of the barriers identified in this research were pointed out by Chin et al. (1994) more than fifteen years ago; the barriers the teachers faced then were:

- Their lack of content and pedagogical knowledge
- Anxiety about maintaining control over the pupils' learning activities
- Factors within the school system such as support from principals
- Time constraints
- Access to relevant resources

The barriers that the primary Science teachers faced are still prevalent in the current research. But only two female and one male teachers mentioned their anxiety about maintaining control over the pupils' learning activities as the barrier. In their responses, they frequently mentioned four major obstacles that hindered optimisation of science teaching, namely:

- Limitation in time
- Lack of content/pedagogical knowledge
- Limited resources / laboratory assistant
- Lack of mentorship and feedback from supervisors

The enablers that were mentioned frequently by female teachers in this research that contributed to the optimisation of science teaching in primary classrooms include:

- Passion for science

- Presence of role-model
- Effective mentoring
- Professional development

5.4.1.1 ENABLERS

Several enablers that aided the female teachers in raising their science self-efficacy were identified from the responses of the teachers. Science teachers reported a passion for the subject as the most important factor. They loved Science since they were young and did not mind going outdoors to be near nature. A similar finding of the female teachers' love for nature and outdoors was reported by Paige (1994).

Throughout their school lives, someone had inspired them tremendously, and that boosted their confidence later in the teaching of Science. The persons could be a secondary, junior college / polytechnic lecturer or college professor / lecturer who had inspired them so much that they emulated those people when they became a teacher.

This same finding was also reported by Paige (1994), that influence and support from key people such as teachers, family, focus teachers, coordinators and university lecturers contributed to the women's expertise in teaching primary Science. A small number of teachers mentioned a family member, a relative or a friend in their responses.

After becoming a teacher, one of the most frequently cited sources of emulation by the female teachers was a colleague, an HOD or a vice-principal. In fact, about a third of the female teachers cited a colleague as compared to only one-ninth for the male teachers. This shows that female teachers need someone, particularly a colleague, to give them the motivation to move on as science teachers.

Teachers also mentioned that workshop, training, course and sharing session pertaining to science teaching had raised their efficacy. Teachers believed that with more time for Science lessons, they could do a much better job of imparting their knowledge. The students' positive attitude and feedback about their Science lessons had also been one of the important motivational factors for the female Science teachers with 10 of them citing it as a factor.

5.4.1.2 BARRIERS

5.4.1.2.1 LIMITATION IN TIME

Plourde (2002) pointed out that the elementary curriculum is overcrowded with a preponderance of non-curricular activities (assemblies, holiday activities, classroom management, state / federal "high stakes testing," specialized programs such as "D.A.R.E." drug prevention, recycling, class elections, etc.) which take away from time being spent on teaching/learning Science. More than a decade ago, Singapore primary teachers indicated that where Science teaching was concerned, there were time constraints imposed by the schools' timetables (Lee et al., 2000).
It is evident that the aforementioned problems still exist 10 years later as shown in this present study; 45 teachers (29 females) mentioned that they faced limited time when Science teaching was involved. Teachers are not only overwhelmed with curricular activities such as their own class to teach and attend remedial and supplementary lessons in the afternoon, but there are also meetings in the afternoon to attend.

Teachers may face not only time constraints in completing a teaching task. Outside the classroom, they also needed time to reflect on their own teaching to see if the lessons had been effectively conducted (Lee et al., 2000).

The teachers also pointed out that the number of periods for science teaching was insufficient and that they did not have enough time to prepare the materials for their science activities (Lee et al., 2000). From the feedback of the teachers, amongst the core subjects of English, Mathematics and Science, the number of periods allocated for science lesson in all Singapore primary schools was the lowest.

The reports from the teachers showed much of their frustration when teaching science was concerned. It had been pointed out that Science seemed to be a "second class" subject compared to English and Math. There were not enough periods to teach the subject in depth, and the students' knowledge of Science is limited, especially in P3 where Science is first introduced.

There were too many things to focus on in only two hours per class to cover subject content, experiment skills, preparation of experiments and pen and paper skills on subject matter. Teachers had to rush through their Science lesson and thus hands-on time for pupils was limited. Shortage of time prevented Science teachers from planning extra lesson to come up with ideas to "stretch" the students' inquisitive minds.

Normally teachers who teach English, Mathematics and Science to a class or any one of the first two subjects with Science have the flexibility to use certain periods to carry out any science activity with their classes. Hence subject teachers were especially affected by time constraints because they teach only one subject to a class. For example, a female teacher wrote that she had to go to other classes to teach science and as a subject teacher, her time with the class was limited to carry out certain time-consuming activities.

Teachers lamented that there were too many process-thinking skills to teach; there was not enough time to prepare teaching aids and a difficult to handle class process especially during experiment lessons. There was insufficient time to go through science worksheets or tests thoroughly. Students ask lots of questions when it comes to science, but teachers pointed that they just had no time to explain in great length to her students. There was not enough time to develop teaching materials / aids and worksheets for to suit the pupils she was teaching.

With the introduction of inquiry Science into the classroom, not only the role of the Singapore Science teacher has changed dramatically, more time is certainly needed to carry out inquiry-based activities in Science. More time then must be added to the Science curriculum to facilitate the aim of inquiry Science in the classroom.

5.4.1.2.2 LACK OF SCIENCE CONTENT/PEDAGOGICAL KNOWLEDGE

The second obstacle that impeded their Science teaching that the teachers mentioned was lack of content/pedagogical knowledge.

In this report, out of the 80 teachers, 26 female teachers reported that the Science was the subject that they consulted their colleagues the most. This is consistent with reports (e.g. Rice, 2005; Riggs, 1991) which revealed that primary Science teachers lack Science content knowledge. Literature in the field has established that elementary teachers are insecure about their low levels of Science subject matter knowledge and that these insecurities lead to negative attitudes toward Science and Science teaching, which resulted in many elementary teachers avoiding teaching Science altogether (Rice, 2005).

Out of the 80 male and female teachers who responded to the question "Do you think you have the necessary/adequate training/education to teach Science", 18 female teachers reported that they did not have the necessary or adequate training/education for teaching Science. As for the 27 male teachers, 21 of them reported that they had the necessary or adequate training/education for teaching Science and 6 of them reported that they did not.

The above results are supported by the response of the teachers in their STEBI-A Question 19: 'I wonder if I have the necessary skills to teach Science'. For the female teachers, the mean score for the above question is 3.25 out of a possible 5 on the STEBI, while the male teachers scored a significantly higher score of 3.81.

It is imperative and urgent then to enhance the female teachers' science content and pedagogical knowledge

5.4.1.2.3 LACK OF LABORATORY ASSISTANT & SCIENCE RESOURCES

There were 14 teachers (10 females) teachers who lamented the availability of resources and equipment for their Science lesson and experiment, and that gathering the above for experiments takes time. Sixteen years ago, Chin et al. (1994) had reported on the similar difficulty and inconvenience the Science teachers faced in obtaining appropriate resources. The obstacles are also consistent with Scott's (1988) finding of teachers not having adequate time to gather together physical resources and to organise investigatory activities.

Unlike secondary schools, not all Singapore primary schools have laboratory assistants to gather resources and facilitate the conducting of experiments in workbooks. This is probably because most of the experiments are considered elementary and teachers should not have any problem accomplishing those tasks. However all these preparation works and experiments, be they be elementary or advanced, take time. A teacher needs to oversee a class of as many as 40 pupils and the duties include the discipline, their safety, the distribution of equipment, the accomplishment of experiments, the cleaning and storing of equipment and most importantly to ensure that the students learn from those experiments. These are to be done in thirty to sixty minutes. What is most frustrating for the teachers is that the experiments frequently fail to demonstrate accurately the outcome of the test – this makes it difficult to convince the students or inculcate certain concepts to them.

5.4.1.2.4 LIMITED MENTORSHIP & FEEDBACK

Teacher education programmes provide the cornerstone for beginning teachers, but the best foundations are made from experience, trial and error and the assistance of a mentor (Plummer & Barrow, 1998).

The lack of mentorship and feedback from their supervisors as a barrier facing female Science teachers is an unexpected finding in this research – we would expect those teachers to have an experienced teacher to guide them when they were teaching Science.

Effective mentoring includes having clear standards and a specific subject focus (Curran & Goldrick, 2002). There were only 8 teachers (5 females) who revealed that they were provided with positive feedback from their supervisors as far as their Science teaching was concerned. Teachers also lamented that their supervisors or mentors were inept in the subject matter as they were not "Science people" and hence their advancement in science teaching was limited. According to Hudson (2004), a key component for teaching science is having pedagogical knowledge, and mentoring in science requires modelling of practice to assist the mentee's pedagogical understanding. Feiman-Nemser and Parker (1992) have shown that pedagogical knowledge can have differences from one subject to the next and, therefore, mentoring must address content-related issues in content-specific terms.

5.4.1.3 GENERAL THOUGHTS OF TEACHERS ON SCIENCE TEACHING

One section of the survey form required the teacher participants to give their general thoughts on Science teaching in Singapore. Some had left this section unfilled, but most of them gave an insight of their thoughts actively which reflect that they were passionate about the subject. Through their recommendations and feedback, we could sense that they were very confident about Science teaching although they were restricted by certain aspects in school.

Teachers found that there was too much paper talk in Singapore, i.e. everyone was simply vying for a paper qualification and ignoring the fun of learning Science. The process of learning Science was often hindered by this and science could be made more interesting if less focus was placed on achieving results.

A teacher complained that there was so much to go through to have a more hands on approach and also discussion so that the students discover for themselves what was happening around them. Children should be given more opportunities to explore the outside world to discover science for themselves.

Children are curious to learn more about animals and their surroundings, hence there should be more trips to the Singapore Zoological Gardens, Botanical Gardens, Bird Park, etc. to let the students explore the real world. More presentation of pictures and screening of videos during Science lessons will definitely stimulate their interest in this subject.

A teacher wrote that Science is part of our lives and students should continue life-long learning of the subject. There should be more emphasis on hands-on activity and projects for self-learning. Pen-and-paper tests should be revamped to show more emphasis on the hands-on aspect of assessment. Some teachers pointed out Science teaching was not as fun as it should be. There was not enough time spent on letting the pupils learn the fun in finding out the new things. The teaching of Science should be to get the pupils to question everything around them and then to allow them to find out answers - not just telling them what the perceived truth is. Once they have the idea that we have already found out everything there is to know about Science, they will not explore and then Science becomes boring.

In this section, most of them had once again voiced their concern that the main factor was time when teaching Science. Science is there to encourage critical thinking skills but they do not have the time to teach that knowledge. Yap gave the most insightful comment; he found that primary school Science teaching is interesting, demanding and challenging but:

> "A lot of time is required to prepare an interesting lesson that can engage pupils. Yet in reality, even if teachers can spend that amount of time to create the best Science lesson, Science (compared to English and mathematics) is given the least amount of curriculum time. As a result, teachers cannot afford to spend more time with their pupils to explore scientific concepts through experimentation (not some of the "silly" experiments in commercially published activity books). In addition, textbooks and activity books that are produced commercially offer too little to attract pupils as their curiosity can no longer be easily satisfied by a few facts and pictures printed in these materials. The latter makes no sense to them as they do not have much real life experience related to these facts since they are given very little chance to see, feel and make conclusion for themselves."

Another teacher commented that time constraints might be especially detrimental to an inexperienced teacher as they might not know how to maximise the teaching periods and may not complete teaching before the examinations.
A teacher believed that Science is fun as teachers and students get to do hands-on.

Teachers are also their "encyclopedia" whereby they try to explain some phenomena that are very new to them. However, primary school Science teaching can be rather tricky especially when some of the explanations included some concepts that they will only learn in secondary / tertiary level. So, primary school teachers are challenged in this area. It is also a subject that they must constantly read up on. Teachers need to be well-versed in the topic so that wrong information is not taught and pupils' queries can be answered in the best possible way.

Several teachers proposed starting formal Science education in primary 1 or primary 2 but they strongly advised that it should not be textbook based. Pupils should be made more aware of their surroundings and links can be drawn between things around them and the Science concepts. There should be more hands-on activities but not examinations or even worksheets.

5.4.2 RECOMMENDATION TO RAISE SCIENCE SELF-EFFICACY AND OPTIMISE SCIENCE TEACHING FOR FEMALE TEACHERS IN SINGAPORE

The TIMMS 2007 shows that primary Science education in Singapore has been on the right track of providing the best kind of Science education to the students and this is the first step towards the nurturing future Scientists of world-class calibre. To keep this mission alive, the Ministry of Education, the National Institute of Education and schools should identify and address obstacles faced by the teachers since they are the ones who could make the difference. Obstacles, if not addressed could potentially further lower the self-efficacy of the teachers, which in turn will affect the students.

Because beliefs about the effectiveness of good science teaching are dynamic in nature and subject to experiences and context, change is possible (Laat & Watters, 1995). In this section I shall make recommendations (some based on the feedback of the teachers I interviewed) that certain actions be taken by individuals who work closely with the female teachers (namely: NIE lecturers or professors, Principals, HODs, Science level heads, Science representatives, colleagues, etc.) to enhance the Science self-efficacy of the female teachers. The recommendations are mostly based on Bandura's four principal sources of self-efficacy beliefs, which are possible interventions to increase the self-efficacy of an individual. They are:

- Enactive Mastery Experiences that serve as indicators of capability
- Vicarious Experiences that alter efficacy beliefs through transmission of competencies and comparison with the attainments of others of others
- Verbal Persuasions and allied types of social influences that one should possesses certain capabilities

- Physiological / Affective States from which people partly judge their capableness, strength, and vulnerability to dysfunction.

5.4.2.1 ENACTIVE MASTERY EXPERIENCES

Bandura (1997) considered Mastery Experiences as the most powerful influence on raising self-efficacy because if one sees that a performance has been successfully attained, it will raise efficacy beliefs which will in turn lead to the expectation that performance will be proficient in the future. The perception that one's performance has been a failure lowers efficacy beliefs, which contributes to the expectation that future performances will also be inept (Bandura, 1993; Pintrich & Schunk, 1996).

Teacher education programmes have an important role to play in developing within student teachers' images of good teaching (Johnston,1992). One of the ways that Schoon and Boone (1998) suggested to increase the confidence and self-efficacy of primary teachers was through the mastery of Science content knowledge. It is surprising to learn that about one third of the female teachers reported that they had not acquired adequate Science content/pedagogical knowledge from the NIE to teach their students; hence the National Institute of Education should look into enhancing pre-service female teachers' Science self-efficacy beliefs by putting more emphasis on the acquisition of content/pedagogical knowledge. From the findings in this research, female teachers certainly require more help than their male counterparts when Science teaching is concerned. And this should begin at the NIE. Tschannen-Moran et al. (1998) proposed that: "Teacher preparation programs need to give pre-service teachers more opportunities for actual experiences with instructing and managing children in a variety of contexts with increasing levels of complexity and challenge to provide mastery experiences and specific feedback. An apprenticeship approach of breaking down elements of the complex task of teaching, allowing an apprentice teacher to work on developing one set of skills at a time, should encourage a compounding sense of efficacy over various contexts and skills" (p. 24).

Palmer (2006) reported that pre-service primary Science teachers' self-efficacy was substantially increased as a result of participation in a Science methods course; this was reinforced by having the opportunity to teach Science in a practicum. For most students the positive effects of a well-designed Science methods course can persist until close to the end of the teacher education programme, especially if bolstered by practical experiences. He further proposed that if the Science methods course is timetabled to occur about one year before the end of their university studies, then one would expect that most students would be graduating and entering their profession with reasonably high Science teaching self-efficacy. He also suggested that a practicum placement should be timed to occur fairly soon after the end of the Science methods course. Finally students should be allowed ample opportunities during the practicum to teach Science to primary children, and this should have the effect of consolidating the positive effects of the methods course.

The number of science courses and opportunity for hands-on activity are significant too. Kristy pointed out that project-based work during her NIE training days had turned her into an expert for a certain topic but the number of tasks assigned was insufficient; she explained in her interview:

> You do an assignment and pick the level, the topic you want to do. Then you get to see different people doing different topics of all that. But you see the thing is, we only learn when we do certain things ourselves. So if I am teaching circulatory system or if I'm doing a project on circulatory system, I would be the expert on this topic. But if I'm not doing other topic, I don't think by you sharing with me I would learn that much.

Kristy agreed that a mastery experience to her is much more effective than vicarious learning, i.e. watching other teachers performing a task successfully. As stated, Bandura (1997) has ranked enactive mastery experience as the first and most powerful influence on self-efficacy in which self-efficacy for a behaviour is increased by successfully performing the behaviour. The National Institute of Education could conduct a review on the number of such project-based work for the pre-service teachers as it could likely enhance the self-efficacy of the trainees.

5.4.2.1.1 SUBJECT SPECIALISATION

The self-efficacy of future female Science teachers could be boosted if MOE's plan of primary school teachers specialising only on certain subjects was implemented.

Two-subject Specialisation meant that English-medium teachers in primary schools typically teach two subjects from choices like English, Mathematics or Science.

The Singapore Ministry of Education recognises the value of having teachers specialise in teaching two subjects instead of three so that these teachers can focus on deepening their knowledge and pedagogical skills. The mastery of Science content knowledge is one factor that has been linked with increased confidence and self-efficacy of primary teacher education students (Schoon & Boone, 1998). Training and deployment of teachers to specialise in two of three subjects is currently being studied.

Kristy, who had a Bachelor of Education (specialised in Science) from the National Institute of Education, is one of the female teachers who had scored very high on the PSTE subscale. She displayed every aspect of a first-class Science teacher and this is what we need from today's Science teachers. Primary school Science is no longer as straightforward as decades ago as claimed; teacher could not simply "smoke their way" through a Science lesson.

With the advent of the internet, primary students have become more knowledgeable and sophisticated. They do not ask childish questions anymore and the Science teachers must be prepared for them. Kristy found that those hands-on activities which required the pre-service teachers to pick a Science topic to present to the class at the NIE had been advantageous but because the pre-service teachers had to do many other activities, such projects were limited to only one. With subject specialisation, the NIE could probably focus their curriculum on project work so that the pre-service teachers could gain a more in depth content/pedagogical knowledge of the topics that they would be teaching to their future students. When they become teachers, they will have more time to spend on the preparation works of their subject(s) of specialisation.

5.4.2.1.2 PROFESSIONAL DEVELOPMENT

The Singapore MOE also recognises the need to continually help teachers develop into life-long learners, current in both skills and knowledge. This process is on-going and one where teachers are active participants in their own growth and development. This is especially important to Science teachers as Science and technology are progressing so rapidly. It is a known fact that inexperienced and new teachers need specialised support, encouragement and multiple opportunities for professional growth (Merseth, 1992).

In 2004, the MOE embarked on the Professional Development Continuum Models for Teachers. According to the ministry, the rationale for the New Continuum Models for Teachers is to promote teachers' professional development by enhancing their teaching effectiveness (through lifelong learning), and supporting their professional growth (through systematic upgrading and higher certification). Throughout this initiative, teachers are encouraged to attain 100 hours of training per year for professional and personal development.

Effective professional development can have a long term effect on how teachers view their self-efficacy (Watson, 2006). It is the most important factor influencing confidence in primary Science teaching (Murphy et al., 2007). Plourde (2002) suggested that student teachers' long-term commitment to the teaching of Science in the elementary school could be sustained through the availability of Science workshops. He further suggested that these workshops should be geared towards elementary teachers with ideas and activities which could be immediately implemented in their classrooms. Activity oriented, hands-on Science workshops held at local elementary schools would facilitate the greatest teacher involvement.

Laat and Watters (1995) advised that in-service science programme "must provide practical experiences that establish a basis for improved classroom effort and more innovative approaches to the implementation and evaluation of science… [and the] design and delivery of such program should specifically recognise self-efficacy conditions and provide attention to motivation" (p. 461).

From the responses of the Science teachers, their schools were active in conducting and promoting professional development. The female teachers believed that their science self-efficacy had been raised through professional development activities such as Science workshops, courses, dialogues, small group discussion and seminars.

Schools with a strong "Science culture" had been doing this all along; this should be extended to any school that wishes to raise the Science self-efficacy and content/pedagogical knowledge of their Science teachers. It is recommended that the Head of Department for Science in every Singapore Primary School share their resources on useful training that are highly regarded by the teachers who strongly believe the course(s) they had undergone benefitted them tremendously.

5.4.2.1.3 LONG-TERM PROFESSIONAL DEVELOPMENT PROGRAMMES

When professional development is concerned, schools cannot just organise intermittent courses, workshops or seminars for their teachers. Cripe (2009) suggested there was a need for more long-term professional development programmes so as to allow teachers to have the time to identify and potentially change both their self-efficacy beliefs and teaching behaviors. In fact, to develop the confidence and competence to teach primary Science, Paige (1994) found that women need access to long-term whole school training and development programmes based on a constructivist theory of learning and support networks in Science. Cripe's (2009) research supported the notion that long-term professional development programmes where the teachers are active participants are instrumental in changing Science teachers' beliefs. Her study also suggested that it is not just the length of the professional development programme that is crucial, but also the need for an implementation period where teachers can practice what was learned in the training with their own students.

5.4.2.1.4 PROFESSIONAL DEVELOPMENT FOR MENTORS

The above suggestion is not limited to teachers but it is also extended to their mentors. The teachers in this research had indicated that they would approach their HOD or supervisor when they encountered obstacles while teaching Science. The cases of Isabella and Candice (both possessed low self-efficacy) further illustrated the implication of having mentors who are less than qualified to guide the junior teachers.

The world of Science is ever-changing. Hence mentors will require constant professional development to stay abreast of current technological advances so as to ensure that mentees receive adequate pedagogical knowledge for primary Science teaching (Hudson, 2004). Hudson (2004) believed that more effective mentoring may occur if a mentor is knowledgeable about how and what to mentoring primary Science teaching. He added that effective mentoring may influence a mentee's primary Science teaching beliefs and consequently, develop the mentee's self-efficacy in primary Science teaching practices. Equipping a mentor with specific pedagogical knowledge for mentoring in primary Science teaching may reduce the number of potential concerns or problems experienced by mentees.

5.4.2.2 VICARIOUS LEARNING

The second information is vicarious learning in which according to Bandura beliefs are often acquired through observation and interpretation, or hearing role models talk of their experiences. In observing the modelling behavior of others, the learner is able to reflect on past experiences with such behaviour and make meaning of its relevance in a new situation. Based on Bandura (1986) and Schunk's (1987) findings, when teachers watch admired credible and similar models teach in skillful and adept ways, it can affect the observer's personal teaching competence. In addition, when observers compared to others the former, particularly new teachers can believe that they also have the capabilities to be successful teachers under similar circumstances.

This again, reiterates the importance of professional development. Female guest speakers, who are Science specialists or experienced teachers, can be invited to talk to the female Science teachers to share their experiences.

The abovementioned finding is very evident in this research. Half of those teachers involved in this research mentioned that their colleagues including HODs and ex-teachers had been most influential in their role as a Science teacher and that they modelled themselves on those colleagues. Most of the teachers affirmed that sharing sessions had enhanced their content knowledge for teaching Science which in turn raised their self-efficacy. Providing Science teachers with sharing sessions can enable teachers to reflect on their individual teaching methods, exchanging notes about their ideas, extent of success and how they can further improve their teaching (Lee et al., 2000).

If information on high-quality courses, workshops, trainings, etc. conducted by outstanding lecturers / trainers that Science teachers had attended are shared with other teachers in other schools, clusters or zones, they will certainly benefit all the Science teachers in Singapore as a whole. For example, teachers in this research had written that one of the major frustrations (one factor that will also affect the physiological and affective states of the teachers) they faced was that they did not know the acceptable answer to those open-ended questions. This is not that they lack the content knowledge of that particular concept, but more that most of the time many teachers did not know what is deemed as "the best answer" for that question as stipulated by the Science department.

In Science open-ended questions for example, the two words 'the' and 'a' if used indiscreetly would be disastrous. All Science teachers must possess the skill of answering technique to inculcate the 'acceptable' answer to their pupils. A school that has encountered someone, whether he/she be a teacher, HOD or a lecturer from an external agency, who knew the best way to inculcate such knowledge then he/she should be made known to all the HODs. The HODs could receive direct training from him/her and in return train his/her fellow teachers or invite the lecturer to the school to train the teachers.

5.4.2.3 VERBAL PERSUASION

5.4.2.3.1 MENTORSHIP & FEEDBACK

According to Schunk (1989), in verbal persuasion, the persuader's credibility is an important factor. Bandura (1997) suggested that to raise self-efficacy in this way, encouragement and the in-depth informative feedback from the learner's mentor is important. The mentor should also highlight the rationale of why some strategies that the learners use are successful and why some fail.

Mentors can be a source of knowledge as well as assist in socialisation; and his / her support skills should include knowing when to listen, when to accept, when to observe, when to praise, when to intervene, when to analyze and when to confront (Kilbourn & Roberts, 1991). Verbal persuasion by peers and superiors though has been found to be a weak source is still important to teachers with little experience in a domain (Ross, 1995).

The feedback of the four interviewees illustrated the importance of mentorship. As the teachers' supervisors, the HODs or level heads are expected to provide regular feedback to the female teachers regarding their Science teaching. Through the responses of the teachers, there was a startling finding. A small number of female teachers mentioned that their supervisors had given them feedback that made them believe they could teach the subject well. Only 8 teachers (5 females) of the 80 teacher participants mentioned that either a colleague / colleagues or a supervisor (HOD, Vice Principal or Principal) had praised him / her since they started teaching Science.

Most of the positive affirmation and feedback that they received was from their own students. A total of 16 teachers stated that their pupils (their positive feedback; their good results, etc) had given them most of the motivation to teach Science.

Tschannen-Moran et al. (1998) reported that "specific performance feedback from supervisors as well as other teachers and even students … can be a potent source of information about how a teacher's skills and strategies match the demands of a particular teaching task. Specific performance feedback provides social comparison information, that is, whether the teaching performance and outcomes are adequate, inferior, or superior to others in a similar teaching situation" (p. 20).

From the teachers' experience, it is imperative for the mentors or HODs to pay more attention to this shortcoming. Supervisors are encouraged to give constant reviews of the progress of female teachers. Mentors of teachers should first assign achievable tasks to those teachers. With persuasion and successful outcome, teachers will then proceed on to the next step of engaging in more difficult tasks.

Bandura (1997) has also pointed out the fact that if a person is persuaded verbally that he or she possess the capabilities to master given tasks, he or she is likely to mobilise greater effort and sustain it. A "pep talk" alone may be limited in strengthening personal teaching competence, but such persuasion can counter occasional setbacks that might otherwise instill self-doubt and interrupt persistence (Schunk, 1989). Persuasory efficacy attributions have their greatest impact on people who have some reason to believe that they can produce effects through their actions (Chambliss & Murray, 1979a, 1979b).

From the interview with Kristy who specialised in primary Science (Biology) at the NIE, we learnt that even those who specialise in Science at NIE could also have a dip in their self-efficacy. She first began with her teaching career high in self-efficacy. This was because she had an inspiring Science HOD who guided her a lot and encouraged her along the way.

As the days went by, a few incidents affected Kristy substantially – not least the Principal's rejection of her proposed projects which she was so enthusiastic to carry out. The Principal had not even given her any feedback and worse not spoken a single word on any proposed project that she had submitted to him.

On her own admission, she began to lose some enthusiasm in her teaching. It was not until a new Vice-Principal who was a former Science HOD took interest in her work and injected some vitality in her that she became more interested again.

Dembo and Gibson (1985) have also highlighted Kristy's problem; they stated that the way in which school Principals interact with their staff, influence school climate, and provide opportunities for decision making affects teachers' sense of efficacy. Principals should consider how they can transform the often impersonal, bureaucratic school into an organization with shared goals and shared responsibilities for decision making (Ash-ton et al., 1983).

The above example also illustrated that a teacher could have a very strong Science background and started out as a Science teacher with high self-efficacy could lose her enthusiasm if the supervisors failed to constantly monitor their subordinates' self-efficacy. This is not just the job of the Science HOD but any supervisor who oversees the performance of the teacher.

5.4.2.4 PHYSIOLOGICAL / AFFECTIVE STATES

Bandura (1997) stated that our own responses and emotional reactions to situations play a critical role in self-efficacy. Moods, emotional states, physical reactions and stress levels can all impact how a person feels about their personal abilities in a particular situation. He advised that through learning how to minimise stress and elevate mood when facing difficult or challenging tasks, we can improve our sense of self-efficacy.

Science teachers lamented that they had limited time to prepare for lessons and had to rush through most of the activities prior to or during lessons. These are added pressure weighing on the already-burned-out teachers. Below are recommendations to reduce the stress level of the Science teachers:

5.4.2.4.1 ALLIED EDUCATOR & LABORATORY ASSISTANT

Female Science teachers complained that considerable time was spent on lesson preparation for Science. One solution would be to seek the assistance of a helper. With the introduction of Allied Educator (Teaching and Learning) all teachers including Science teachers will have a partner to work with to enhance the teaching and learning of primary school students in both academic and non-academic areas.
Their responsibilities (according to the MOE, 2010) include providing teaching and learning support for students within and outside the classroom. They will help the teachers by undertaking co-teaching responsibilities:

- Providing specific and differentiated learning and remediation support for individual or a group of students
- Assisting in lesson planning
- Administer tests
- Evaluate students' work
- Assisting in developing additional learning support programmes for students

- Assisting in building of teaching and learning resources

In implementing such an initiative, the ministry or the school administrators should have a plan for the Allied Educator to help Science teachers. Science teachers have been lamenting that they do not get the chance to work with any Allied Educator in their work.

As such, the job scope of the Allied Educator in the area of Science could include ensuring the availability and gathering of resources for Science lesson and experiment; organising of outdoor activities pertaining to Science, etc. Almost every secondary school currently has laboratory assistants to help prepare for Science experiments which are multifaceted, so why not in primary schools?

Unlike in the past, primary Science experiments are fast catching up with their own complexity as the Science syllabus became more demanding to be in line with the ever-changing world. With the Allied Educator, the teachers would have more time to read up on more books pertaining to the topics that they were going to teach to the students and time for other preparation works.

5.4.2.4.2 EXTENSION OF TIME FOR SCIENCE LESSON

As early as ten years ago, Lee et al. (2000) had reported that time was one of the main obstacles that Science teachers in Singapore faced. Problem solving activities in Science teaching could not be done on a frequent basis. Due to this obstacle, the teachers resorted to demonstration and the expository teaching approaches. Many teachers also pointed out that they felt the stress of not having enough time to prepare the materials for their Science. Ten years later, the majority of the female teachers in this current research indicated that time as the major obstacle in optimising science teaching; they had limited time to prepare for Science subject content and experiments, and to develop experiment skills.

Teachers in this research questioned the imbalanced number of instructional hours allocated to the three core subjects of English, Mathematics and Science (lowest amongst the three subjects) when they are given the same importance in examinations.

As such, Principals or the MOE must consider extending the hours/periods of Science lessons in schools. Additional time should be given to Science teachers outside of curriculum time in preparation of their lesson. This should not be achieved at the expense of the Science teachers' rest time. Surely we do not want to conduct a similar research ten years later and find that limitation in time is still a major obstacle for the Singapore primary female Science teachers.

With more time, Science teachers will have more time to prepare for and conduct lessons and experiments, more time to inculcate concepts, use the internet in class to answer pupils' 'difficult' questions and visitation of interesting places for Science. More time should also be allocated for self-improvement in the area of Science as female teachers indicated that they did not possess adequate training and education in science.

As mentioned in my introductory page on inquiry Science into Singapore primary Science classrooms, the role of the Singapore Science teacher has changed significantly to become the leader of inquiry who imparts the excitement and value of Science to their students. They are the facilitators and roles models of the inquiry process who create a learning environment that will encourage and challenge students to develop their sense of inquiry. As such Science teachers would need more time in terms of lesson preparation. This would include looking for resources and better ways of teaching the students; preparation of experiment apparatus and bringing the pupils outdoors instead of just conducting the Science lessons in the classroom or laboratory.

Such activities are conducted not for the sake of training the students to be prepared for their examinations but to promote the inquiry process, ass one teacher participant had lamented that Singapore education system is too exam-oriented. Those activities would not be possible without the extension of time.

5.4.2.4.3 TIME FOR OUTDOOR ACTIVITIES

Carrier (2009) proposed that "Science education in elementary schools should expand beyond the four walls of the classroom. Many opportunities abound in the outdoor setting for learning about science. Environmental sciences include topics such as nutrient cycles, ecological awareness, and the water cycle, allowing students to personally experience many learning opportunities in the outdoor setting" (p. 35). Teaching concepts in the setting studied, such as the outdoors, holds tremendous value for providing authentic learning experiences for students (Cronin-Jones, 2000).

Carrier (2009) emphasised the need for pre-service teachers to be exposed to authentic settings for Science instruction during their Science methods courses. She believed that in order to gain experience and receive feedback, teachers need to have opportunities during their teacher education programmes to instruct and interact with children in similar settings to which they will be teaching. In her research, Carrier found that the pre-service teachers were initially apprehensive before their trip outdoors for environmental Science lessons but their enthusiasm increased when they witnessed the students' excitement for the outdoor lessons and the learning apparent during the field observations.

It was also a common theme in both the written end-of-the-semester reflection papers and during the interviews conducted seven months after the completion of the course. The pre-service teachers' successful field experiences emphasise the power of modelling and the positive impact of their observing students' excitement about learning Science. By modelling engaging, inquiry-oriented Science activities for pre-service teachers, Carrier (2009) believed that Science teacher educators can encourage them to strive to provide Science inquiry opportunities with their future students. She added that witnessing the students' eagerness for learning Science in the outdoors during their Science methods course can provide pre-service teachers with positive reinforcement for using the outdoors to conduct Science lessons when they become teachers.

Science is a subject that is "alive". Unlike English and Mathematics which are mostly textbook-based with the exception of Mathematics in which manipulative could still be used to enhance learning, many Science activities should be conducted outside of the classroom.

From the feedback teachers gave in the 'General thoughts' section, activities such as taking students to the Science Centre, Discovery Centre, Singapore Zoological Garden, Bird Park, nature parks or taking them to the school eco-garden are essential and should be held regularly. Science teachers should not just rely on the internet to show their students the 'world'. The latter has to experience it themselves in real life scenarios.

If we were to take a look at the Primary 3 syllabus, the few topics that the students learn are about animals, plants, fungi and micro-organism. For Primary 5, some of the important topics are plant transport system, the water-cycle, seed dispersal, pollination, etc. It is a no-brainer to know that those topics have to be conducted outside the classroom so as to optimise Science learning. Those activities which students always look forward to are however organised infrequently.

5.4.2.4.4 FEASIBILITY OF STARTING SCIENCE EDUCATION BEFORE PRIMARY 3

While it is easily said than done to simply suggest allocate more time for Science, curriculum planners might oppose such a move and argue that there are other core subjects and activities that have to be completed. In Primary 3, the pupils will be required to sign up for at least one CCA; some schools would have started a new subject for the students called higher mother tongue. What is left is minimal time for any extension to the Science lessons.

In the beginning of this thesis, it is reported that many researchers have advocated that Science education should start at an early age. In fact, at the infant stage seems most appropriate for some of them (e.g. Duckworth, 1996). Young children are naturally curious about the things like the animals and plants around them. Teachers in this research also supported the idea of starting science in primary one. While schools are at their liberty to plan their Science curriculum (although it must be based on MOE approved textbooks only), many schools would likely begin at the most fundamental Science topics of diversity (refer to page 13 on the Singapore Primary Science curriculum). Diversity (mainly Life Sciences) which includes living and non-living things, animals, plants, fungi and micro-organisms, the life cycle and materials is recommended to be taught in Primary 2.

Those are the topics that always intrigue the children when they first learn about Science. Most schools need one semester to complete the above topics – if the Science syllabus is incorporated into the primary 2 curriculum, it is suggested that those topics be taught in two semesters. It is hoped that with this suggestion, Science teachers will have more time in subsequent terms, semesters or years to prepare other Science lessons or conduct more inquiry-based activities with the students.

5.5 CHAPTER SUMMARY

In this chapter the summary of the four interviews with the teachers, and the findings (primary and secondary aims) of the research is reported. Next the teachers' responses on the enablers and obstacles they faced while teaching Science is discussed. Finally recommendations to raise the Science teachers' self-efficacy through Bandura's four interventions are proposed. Through subject specialisation, female Science teachers will be able to focus on deepening their knowledge and pedagogical skills.

Female Science teachers should undergo a constant professional development programme as it is the most important factor influencing confidence in primary Science teaching.

Professional development programmes for mentors ensure that they are more effective in mentoring and their mentees receive adequate pedagogical knowledge for primary Science teaching. School should consider extending the time for Science lessons so that Science teachers will have more time to prepare and conduct their lessons.

More time for outdoor activities is not only beneficial to the students, but the teachers will also stand to gain from it. The pre-service teachers' apprehensiveness before outdoor trips turning into enthusiasm when they witnessed students' excitement for the outdoor lessons could be a positive reinforcer for future Science teaching. Science educationists have supported the idea that Science education should start early, even as early as kindergarten. In this way, Science teachers from primary 3 and beyond will have a reduced content to cover, thus cutting down on the problem of limited time for lesson.

CHAPTER 6

CONCLUSION

This final chapter reflects on the unique contributions, the limitations of this study and the things I would change. Implications of the findings are also discussed and future research studies will be suggested.

6.1 THE UNIQUE CONTRIBUTIONS OF THIS STUDY

- There are several strong points of the research. The 80 teacher participants were chosen from primary schools all over Singapore. The teachers are of different ethnic backgrounds and came from different school types and cultures teaching different levels. The research also used the STEBI –A which has been validated and used by many researchers to measure teacher efficacy.

- The 80 teachers and 4 interviews gave us a deeper understanding of the enablers and barriers experienced by faced by Singapore female Science teachers.

- Most of the studies on self-efficacy of teachers were generally from North America, Europe or Australia. There was hardly any research on the Science self-efficacy of female primary school teachers and their male counterparts in Asia. The uniqueness of this study lies in the fact that it is probably the first one to measure and compare both the Singapore male and female primary teachers' Science self-efficacy. It contributed to the existing knowledge by yielding much information about the current enablers (their passion for Science, a role model during their time as a student, a colleague who guided them, the positive feedback and attitude of their students, supportive supervisors, etc.) and barriers (content knowledge, limited time allocated for Science, limited resources, limited mentorship, etc.) facing both the Singapore male and female primary Science teachers in Singapore, a country whose 4^{th} graders had achieved outstanding results in the last few TIMMS. One new barrier identified in this research is the lack of mentorship / feedback from the female Science teachers' supervisor.

- With these findings, future researchers will be able to use the reports in this thesis to further investigate and compare the results with the self-efficacy of other primary Science teachers in other countries.

6.2 LIMITATIONS OF THE STUDY

Although utmost care has been exercised while designing and implementing this study, I must advise against over-generalisation of this report. This study has the following limitations:

- The literature review has drawn primarily on studies from North American, European, Australian, etc. and only a few studies were carried out in Singapore or South East Asia. As advised, there is important class, racial, and cultural differences across these samples even within a country that are likely to affect the nature and extent of gender differences observed. The strength of the relationships among the genders, interest in areas of study and academic achievement varies across countries (Evans et al., 2002) and race may be as important as, or even more important than, gender in determining success in Science areas (Hanson, 2004).

- As this is just an independent study, it was close to impossible to obtain permission (lots of red-tape) from either the ministry or any of the principals to do a sit-in in any class when a Science lesson was in progress. Such opportunity would have allowed me to gain a more in-depth knowledge of the classroom practice of those Science teachers who had been interviewed.

  If further permission had been granted, I would have also interviewed the Principal, Vice-Principal or Science HOD of those schools to whom I had sent the survey forms, to learn more about the barriers the teachers faced, and on how the school improved the self-efficacy of their Science teachers. As considerable time had been spent on preparing for the survey, there was not enough time to conduct interviews with more female teachers; 10 to 12 interviewees would have been ideal to have a larger pool of data for analysis. Furthermore, if time was not an issue, I would have interviewed male Science teachers too. This would have further deepened our understanding of the experiences of all the primary Science teachers in Singapore.

6.3 IMPLICATIONS OF THE STUDY

In the following, the implications as a result of this study for the school teachers, for the school administrators, for the policy makers at the National Institute of Education and the Ministry of Education are discussed.

6.4 IMPLICATIONS FOR TEACHERS AND SCHOOLS

This study allows the primary teachers to reflect upon their Science teaching in class and in particular the female teachers. Teachers of both genders should recognise that each of them has their strengths and limitations, and the common problems they face as Science teachers.

They should be more forthcoming in discussing the barriers and enablers they face while teaching Science. The first two teachers with low Science self-efficacy advised that they did not have suitable mentors or reporting officers who specialised in primary Science to give them the best guidance, and that it was up to their own devices to look for the right person who can guide them.

Isabella recommended that pre-service or new teachers be assigned Science teachers who had been proven to be excellent Science teachers for observation. This is a feasible recommendation because, as pointed by Bandura (1986), vicarious learning in which beliefs are often acquired through observation and interpretation or hearing role models talk of their experiences, can increase self-efficacy. If teachers have initial successful experiences in teaching Science, they should develop high levels of self-efficacy that would motivate them to persist with the task (Bandura, 1986; 1995).

Through observation of the modelling behavior of others, i.e. mentor and reporting officer, the pre-service or new teacher will be able to reflect on past experiences with such behaviour and make meaning of its relevance in a new situation.

In particular, the supervisors should give female Science teachers- especially new ones constant feedback so that their teaching effort could be affirmed. And, through this, the latter could work on it and progress to be a better teacher.

Teachers had pointed out that their mentors were not “Science people”. It is hence suggested that supervisors who acted as mentors should possess adequate and relevant training in the field to be able to guide the new teachers or teachers who face problems in their Science teaching. Continual training should also be planned for the mentors as suggested in several researches.

An important emphasis for elementary Science teacher education would be to educate administrator in elementary Science teaching. Administrators should be educated in how to provide proper support in teachers' efforts to reform their teaching to be in line with current recommendations (AAAS, 1993; National Research Council, 1996, as cited in Dickinson, 1997).

School administrators could also consider the proposal of Lomask and Baron (1995) who suggested a three-year support and assessment program called the ‘Science Education Support and Assessment Program (SESAP)’, for new teachers instead of limiting programs to first-year assistance.

The programme comprises of formal seminars on basic teaching skills during the first year where the teachers develop a teaching portfolio. The portfolio consists of planning a unit of learning, teaching and building a positive learning environment, assessing student learning and analysing and reflecting on teaching. In the following year, the teachers identify and propose solutions to problems they have encountered so as to develop and refine their pedagogical knowledge and skills.

Mentoring is also an integral part of the second year. The final year is open for the teachers to define their own individual goals and to participate in professional development activities. Such a suggestion is definitely feasible as the transition from a pre-service to a full-fledged teacher is well monitored.

6.5 IMPLICATIONS FOR THE POLICY MAKERS AT NIE & MOE

The research has shown evidence that female teachers have lower self-efficacy than their male counterpart. The barriers faced by the Science teachers particularly the female ones have been presented. By addressing the barriers the female teachers faced, their self-efficacy could be improved.

The majority of the teachers lamented that time was the main hindrance to effective Science teaching. They lacked time in planning for Science lessons; in preparing for and conducting science experiments; in teaching Science to their students as it has the fewest number of lessons amongst the three core subjects. Their stress level rises inadvertently which affects their self-efficacy.

The limitation of time faced by Singapore Science teachers has been a perennial issue since it was reported by Lee et al. (2000). The ministry may want to re-think the possibility of adding a few more periods to the Science curriculum in schools in order to solve the problem of shortage of time in Science teaching especially with the introduction of the inquiry-based Science in primary. Letting the primary school students start Science education before primary 3 also seems to be a feasible proposition that is advocated by many Science educationists.

The first two teachers whom I interviewed and many female Science teachers had also acknowledged that they lacked Science content knowledge and that NIE had not adequately prepared them for Science teaching in primary school. This is consistent with numerous studies conducted overseas, e.g. Rice (2005), who found the teachers lacking in Science content knowledge.

As such, the MOE should focus more on the Singapore pre-service female teachers. They can re-examine the current Science curriculum for the pre-service teachers before they are deployed in schools to begin their career. Kristy's comment on getting the pre-service teachers to be more involved in hands-on activities could help. This is in consistent with Bandura's (1997) recommendation who ranked enactive mastery experience as the first and most powerful influence on self-efficacy in which self-efficacy for a behavior is increased by successfully performing the behaviour (strongly related with regular physical activity).

Bandura may have agreed that the second information, i.e. vicarious learning, in which beliefs are often acquired through observation and interpretation, or hearing role models talk of their experiences, may not achieve the desired outcome as Kristy has pointed out. She strongly believes that they have to get teachers more familiarised to the content knowledge. If they are confident and comfortable to teach something that they know very well, then there would be more Science teachers around.

The MOE could also recommend to schools highly regarded Science courses or workshops that would raise the self-efficacy of the teachers, male or female. Modules that they took previously in schools or at NIE when they were students might not be relevant in today's world. To be a good Scientist, one needs to constantly learn and discover the world around them. So what about Science teachers who are directly responsible of the future Scientists? Should not they be like the Scientists who constantly explore the latest trend pertaining to the subject?

Though teachers mentioned that NIE had designed their Science programme to incorporate experiments, they were insufficient as most of them were 'touch and go' activities. Since enactive mastery experience has been seen as the first and most powerful influence on self-efficacy, the NIE should consider planning for more hands-on and outdoors activities (such as one proposed by Carrier) for its trainees.

Teacher education programmes that strive to provide pre-service teachers with positive experiences working with students can create opportunities to build their self-efficacy in teaching Science (Carrier, 2009). Carrier's study offers one example of an outdoor programme that positively impacted pre-service teachers' (possibly current Science teachers' too) attitudes and impressions in regards to Science education.

6.6 RECOMMENDATION FOR FUTURE RESEARCH

My study has not only revealed much information on the self-efficacy of female primary Science teachers in Singapore, and the barriers and enablers they face, but it has also led to even more questions. I would like to recommend research that can be undertaken in future; they are as follows:

Research could be conducted on the Science programme at the National Institute of Education and pre-service teachers who have gone through their Science modules to ascertain the strong points and most importantly the weak points of the programme. As about one third of the teachers found that they had not received adequate Science training prior to their career at schools, the Science programme must be tailored for them, for many pre-service teachers are not Science majors in their previous schools.

In the beginning of this thesis, I pointed out that Singapore and Slovenia were the only two countries with no significant difference in the scores between the male and female 4th graders amongst the 58 countries. It will be interesting to measure and compare: 1) the Science self-efficacy of these primary school girls against the boys in Slovenia and/or with the Singapore boys and girls; 2) the Science self-efficacy of the Science teachers, both male and female, of those two countries. From the results, Science educators will learn the strong points from each other.

There has not been any research comparing the Science self-efficacy of the boys with the girls in Singapore primary and secondary schools. In addition, there has been also no research on the difference in self-efficacy between pre-service and in-service male and female primary teachers. In this way, we can learn how much the Science programme that the NIE catered for their teachers has helped improve the Science self-efficacy of the male and female teachers.

Future research can also be conducted on male teachers of those enablers that made them better Science teachers. The current study did not take into account years of service the teachers had undergone. For future research, the years of service for both the male and female teachers should be comparable, i.e. the research could compare the Science self-efficacy of male and female teachers for example with three to six years of service.

The MOE has initiated the subject specialisation for teachers in primary school. Future research could also be conducted on the difference in Science self-efficacy between current female Science teachers and future female Science teachers who have gone through the subject specialisation course at the NIE.

6.7 SUMMARY

In the beginning of this thesis, I stressed the importance of Science education - particularly in Singapore with the government's ambition to turn the country into the forefront of Life Sciences research. Apart from Life Sciences, the government is also feverishly investing or trying to attract foreign investment in other lucrative scientific sectors like Engineering and Information Technology. This will require a large pool of highly motivated and knowledgeable doctoral students and Scientists to fulfill the dream.

The country cannot however just rely on foreign talents to do the job. Instead, more of her citizens should be trained to be the Scientists of tomorrow. To begin with, the job of the primary school teachers is of paramount importance and I have stated how significant their job is to nurture the children.

Self-efficacy has been demonstrated to be one of the most important factors to determine if the children can succeed in school. The persons who will directly influence them in their self-efficacy will be mostly likely the first Science teacher they meet in primary school. The teachers in this thesis have constantly reminded us how their ex-teachers in primary school, secondary school, junior college / polytechnic, or university, had inspired them in Science. With this in mind, the self-efficacy of the primary Science teachers cannot be ignored - in particular the female teachers who make up the majority of the primary teachers in Singapore.

The thesis sets out to measure and compare the self-efficacy of Singapore female Primary School Science teachers with their male counterparts. I hypothesised that the former would be lower than the latter in both the PSTE and STOE.

After analysing the quantitative data from the STEBI-A, the findings showed that the trend is probably reflective of the phenomenon that male teachers have higher PSTE than their female counterpart though the data does not support this claim.

The data also allows me to identify the highly and lowly efficacious teachers. Through the collection of qualitative data of interviewing the four outlier teachers, I gained a rich understanding of the teachers' experiences.

This research contributed to the general research on self-efficacy by providing our foremost understanding of the self-efficacy of Singapore male and female primary Science teachers whose students had done outstandingly in past TIMMS. Through their responses, we learnt more about the enablers and obstacles that affected their proficiency as Science teachers, and through the four semi-structured interviews with the teachers, we gained a deeper understanding of their experiences. For example, for those female teachers with high Science self-efficacy, they had a passion for science since they were a child and before becoming a teacher, someone had inspired them tremendously. When they became in-service primary teachers, they were guided by supervisors and colleagues who inspired and assisted them along the way in their Science teaching.

Other enablers that helped in optimising Science teaching include Science workshops, trainings, courses, sharing sessions and any training pertaining that the school organised and the students' results and positive attitude and feedback on the teacher's Science lessons.

On the other hand, primary Science teachers encountered more barriers than enablers. High on the list of barriers was the limitation of time. They also mentioned limited resources, an absence of a laboratory assistant, inadequate training (at NIE) and education, lack of content/pedagogical knowledge, and limited feedback/mentorship from their supervisors about their Science teaching.

To raise the self-efficacy of the female Science teachers, I made several recommendations. The first is to extend the curriculum time for Science which is much shorter as compared to the English and Mathematics subjects. Better professional development programmes need to be catered especially for the needs of female teachers and their mentors. The Science laboratory not only should be better equipped but there should be a laboratory assistant to help teachers prepare and conduct experiments with the students. There should be more hands-on training through project work and outdoors activities at the NIE or even in schools for as we know by now, mastery experience is the best method to improve self-efficacy for any given task.

Lastly the Science courses for pre-service teachers at the NIE could be improved and they should be more selective in the deployment of Science subject lecturers at the NIE. The lecturers should not solely inculcate knowledge to the pre-service teachers based on Science research reports, but he or she must be ones who were once successful Science teachers in their respective schools whom the female Science teachers could model themselves on. Mentors should continue to receive professional training to better guide the mentees. Constant feedback must be given to the Science teachers about their performance. Through mentoring, both the mentors and mentees will reap the benefits of the process.

6.8 CONCLUDING REMARKS

I must salute all those Singapore Science teachers especially the female ones who have been working so hard to elevate the name of Singapore to the world stage. This is a feat most envied by many other countries in which a small island country like Singapore can compete with the others to be number one for primary Science. Despite the challenges and difficulties the female teachers face, they continue to preserver and inculcate invaluable knowledge to their pupils. Obviously this would not be possible without the policy (though not completely perfect yet) implemented by the Ministry of Education. It is my hope that my thesis would inspire some people to make further improvement and development to our current Science programme to scale even greater heights, not only in terms of the students' performance in examinations, but also how we manage to raise the self-efficacy of all our Science teachers, be it male or female or new or experienced teachers.

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PERSONAL REFLECTION

The thought of doing my doctorate had been rooted in me since my days at NYU in year 2000. If not for my family and work commitments, I would have stayed back in New York to complete it way before the year 2005. I thought I would never do my doctorate ever again – for it was just not possible to do it full-time overseas anymore.

Then the opportunity to fulfill my dream came to me once again. I chanced upon an advertisement in the papers that one of the leading British education colleges, Durham University, was extending their presence to Singapore. What was most exciting was they were sending their UK professors to Singapore for all their lectures. I spent five years going through the American educational system – it would be really exciting to be taught by British professors - something fresh, I reckoned. Before the start of the course, the interviewer, Professor Mike Byram advised me about the rigorousness of the Doctor of Education programme at Durham University. It requires both discipline and perseverance, and with my then work commitments, he thought I had better think twice before undertaking it.

Nevertheless I took on the challenge and embarked on the route of uncertainty for the next five years with Durham University. The long lectures on weekends and evening classes coupled with preparatory works before classes were, to be frank, torturous. The demanding coursework of six 5000-word assignments seized all my nights of rest and all my weekends of leisure. With each module the number of students in class dwindled (the rigorous programme must have taken a toll on them) and I must admit there were also times I contemplated quitting the programme immediately after the thesis proposal.

I told myself I would never be able to survive another two years of sleepless nights for the thesis. And, before I knew it, I had passed the final coursework of Thesis Proposal and embarked on two years of dissertation. The first few months of the thesis was the worst – because my research involved full-time MOE teachers, many teachers simply refused to participate in the survey for fear of any repercussion; some friends and ex-colleagues even refused to reply or take my call after learning about my intention to interview them.

My supervisor knew my problem and agreed that 40 teachers as participants would suffice for this research. Nevertheless I strongly believed that I would be able to persuade more teachers to participate if I pushed harder. In the end 80 teachers took part in the research, with four female teachers agreeing to attend my interviews. The next one year was spent on data entry, data analysis, churning out findings, writing, improving, etc.

I tried my best to complete my thesis as soon as possible. At the age of 89, my dearest grandmother's health was failing drastically, and I just wanted to put on the regalia to show her that one of her grandchildren is already doctor. Unfortunately she passed away peacefully one year before I could complete it. That was one of the greatest regrets in my life.

Weeks before the defence were most nerve-wrecking. Would I pass? Would my 6 years of hard work go down the drain? Would I be asked to spend another year doing the correction, or worst of all, go for another defence? Such negative thoughts would have gone on and on if not for Prof. Remedios, my supervisor, who was always most encouraging. He always assured me that I would be fine.

I was rather fortunate to meet two strict but kind examiners. They made my experience at the defence so enriching.

With a Doctorate in Education and knowing that I have graduated from a top education university in Britain, I will soon embark on my next phase of life. I hope what I have garnered from my 5 years of education will help to inspire and nurture as many children as possible. I want to thank my colleagues at Durham University again and those who have assisted me in one way or another throughout the process.

(I would appreciate it if you could send me an email to give me your comment about my thesis. Thank you)

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