PRIMARY SCIENCE CURRICULUM IMPLEMENTATION IN MALAYSIA: INQUIRY AS HOPE AND PRACTICE

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Jeannie Ling Ai Yieng

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ABSTRACT

Malaysia is gearing towards becoming a fully industrialised country by the year 2020 as envisaged in the nation's 'Vision 2020'. The decline in the number of students taking up science in upper secondary schools over the last decade has caused great concern among many politicians and science educators over the availability of skilled manpower necessary to achieve the nation's vision. Various measures have been introduced to promote students' interest in taking up science, among which was the introduction of an inquiry-based science curriculum for all primary schools in 1995. While understanding of basic scientific concepts continues to be an important goal of the new curriculum, the curriculum also emphasises the development of thinking skills, scientific skills, scientific attitudes and moral values.

A qualitative case study methodology was employed to study the status of implementation of the inquiry-based primary science curriculum in two Malaysian schools. The study focused on five experienced teachers each observed teaching a series of lessons on 'Animal Reproduction' to primary four pupils. Semi-structured interviews were conducted to find out the teachers' views and understandings on matters related to science, science teaching and learning, and the science curriculum. Some sense of the science context in the school was established through interviews with the respective head teachers. Documents and records such as school calendars, minutes of meetings, teachers' record books, pupils' science exercise books, and science test papers were also analysed to supplement data collected from classroom observations and interviews.

The results of the study reveal that the teachers practised teacher-centred instructional strategies, presenting facts and information directly to the pupils and largely neglecting the aspects of curriculum which deal with the development of skills and attitudes. There was little opportunity for pupils to learn science concepts through practical work and inquiry. Inadequate teacher preparation, poorly designed curriculum materials, an inappropriate assessment system, incongruent socio-cultural context of learning, and lack of professional and organisational support were identified to be among the factors which contributed to the teachers' inability to effectively implement the inquiry-based science curriculum. Appropriate actions need to be urgently taken to rectify these problems. Otherwise, we may be witnessing another generation of science teaching where inquiry learning is simply an espoused aspiration. The vision of developing pupils into the self-reliant, creative and innovative individuals as advocated in the science curriculum remains distant.

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CHAPTER ONE

INTRODUCTION

Education is regarded by many developing countries as the most important key to building a successful nation. Malaysia too has given a high priority to educational development and has invested extensively in science education since the country's independence in 1957. More recently, the emphasis on science and technology has been reiterated as the country is gearing towards becoming a fully industrialised nation by the year 2020. Various measures have been introduced to promote students' interest in taking up science to meet the demand of manpower in science and technology related professions. One of these was the introduction of an inquiry-based primary science curriculum in 1995. Teachers were provided with various curriculum materials such as the syllabus guide, textbooks, teachers' guides, workbooks and modules. Some teachers also attended orientation courses regarding the new curriculum. These were aimed at facilitating the teachers to shift from a traditional approach to science teaching which focused on pupils' acquisition of scientific knowledge to an inquiry approach emphasising on pupils gaining meaningful understanding of science concepts. However, the School Inspectorate Reports (Ministry of Education, Malaysia, 1995d, 1996e) and findings of various studies (Ministry of Education, Malaysia, 1993b, 1997a; Syed Zin & Lewin, 1993) revealed that teachers continued to use the traditional approach to teach science and that there was very little inquiry learning in science lessons.

This study aimed to investigate how five experienced teachers in two suburban Malaysian schools implemented the new primary science curriculum. The study further explored how these teachers' personal and contextual factors influenced their classroom practices. This chapter provides an overview of the Malaysian education system which includes its historical background, the structure of the education system focusing on primary school education, the development of science education, and the meaning of education to the Malaysian public. This is to provide the readers with a broad understanding of the context within which the study was done.

1.1 The Malaysian Education System

1.1.1 Historical background

Malaysia occupies two distinct geographical areas, Peninsular Malaysia and East Malaysia separated by the South China Sea. It has 13 states and two federal territories. One notable feature of Malaysia is its multiracial composition with distinct cultural diversity. This includes the Malays, Chinese, Indians as well as other indigenous ethnic groups such as the Ibans, Melanaus, Bidayuhs, Kadazans and Muruts in the East Malaysian states of Sabah and Sarawak. Though Islam is the official national religion, freedom of worship is guaranteed in the Constitution. Bahasa Malaysia is the National Language. English is widely used and is a compulsory subject in all schools.

According to Wong (1973), the education system in the pre-independence period seemed unplanned as there was no clear policy on the part of the government with regard to the role of education in the development of the society. Educational development was subjected to the general objectives of the colonial authorities, whose main concern seemed to be to maintain the status-quo of the different communities in the country. The Malays, Chinese and Indians developed their own school systems using their own languages as the medium of instruction. It was only in the English schools that children from all races came together. These English schools adopted educational programs that followed the British model. The Chinese community organised their own primary and secondary education. These schools were taught by teachers from China using textbooks and curricula from mainland China. The Indian schools also had their teachers brought in from India using curriculum materials from India. The Malay schools were religious schools, focusing on Islamic teaching. The educational institutions were essentially a divisive force in the society tending to sustain its ethnically plural character.

After World War II and continuing after independence in 1957, the government developed an education policy based on the Razak Report (Report of Education Committee, 1956) and Rahman Talib Report (Report of Education Review Committee, 1960) to bring all schools into a national system of education with a common content syllabus and using Bahasa Malaysia as the medium of instruction. Both steps were part of the drive towards developing a common Malaysian outlook and attitude. The Education Act (1961) provided the legal basis for:

i. the national language as a compulsory subject at all levels in primary and secondary schools and in all teacher training institutions;
ii. the setting up of secondary schools or classes to be taught in the national language; and
iii. a pass in the national language compulsory for the award of certificates for public examinations at the end of lower and upper secondary levels.

Bahasa Malaysia is the medium of instruction at all levels of the education system, including post-secondary and tertiary levels, except in the primary Chinese and Tamil schools.

1.1.2 Overview of the Malaysian school structure

Education in Malaysia is centrally controlled by the Ministry of Education which prescribes the supply and transfer of teachers, head teachers and principals, the placement of students, the curriculum, the textbooks, the examination system and a host of other aspects. Even though there are various types of primary schools and secondary schools in Malaysia as shown in Table 1.1 and Table 1.2, all of them follow the same curricula. All school curricula in Malaysia are prescribed through syllabuses developed by the Curriculum Development Centre locally known as Pusat Perkembangan Kurikulum (PPK) within the Ministry of Education. All local acronyms used in this thesis are listed and explained in the glossary. In recent years, all schools are also required to use the textbooks, workbooks and teachers' guides published by the Ministry of Education. This is to ensure that they follow the guidelines of the mandated curricula. However, many schools and teachers adopt the use of commercial books for their students as they feel that the materials produced by the Ministry of Education are inadequate to maximise students' performance in the examinations. It is also the practice that every ten years, a committee within the PPK would be set up to scrutinise the existing syllabuses to ensure that they are in line with those in other parts of the world.

After the non-compulsory pre-school years, the formal school system in Malaysia has a 6-3-2-2 pattern which characterises the length in years of the primary, lower secondary, upper secondary and pre-university levels respectively, with pupils entering the system at the age of 6+ years. The pattern of movement through the Malaysian education system is presented in Appendix A. At present, the school leaving age is 15 years, made possible through automatic promotion throughout primary and lower secondary levels, though students are required to sit for national examinations at these levels.

Table 1.1: Number of Primary Schools, Classes, Teachers and Pupils in Malaysia as at 6 January 1997

Types of Schools	Number of Schools	Number of Classes	Number of Teachers	Number of Pupils
National Schools (Bahasa Malaysia)	5244	65606	116978	2168354
National-Type Chinese Schools	1282	16685	27062	601891
National-Type Tamil Schools	530	3983	6108	98072
Special Schools (for pupils with disabilities)	28	295	533	2350

(Source: Internet website: http://www.moe.gov.my/)

Table 1.2: Number of Secondary Schools, Classes, Teachers and Pupils in Malaysia as at 6 January 1997

Types of Schools	Number of Schools	Number of Classes	Number of Teachers	Number of Students
Regular Schools	1375	47554	87020	1720518
Fully Residential Schools	37	886	2479	21396
Vocational Schools	47	723	3007	14211
Technical Schools	31	505	1857	12358
Religious Schools	45	929	2038	25508
Special Schools	3	64	122	524

(Source: Internet website: http://www.moe.gov.my/)

In the present formal system of education, there are six standards at the primary level followed by three years of lower secondary education after which they move to the upper secondary level for a further two years. This is followed by another two years at the Form Six level which is essentially in preparation for the university though physically, they are located within the secondary schools.

Most schools are either government or government-aided schools which receive financial aid as well as their supply of teachers from the Ministry of Education.

Primary and secondary education in these schools is free. Students pay a consolidated fee towards sports and library costs. Common national curricula for all schools, the use of Bahasa Malaysia as the national language, centralised examinations at specific stages, and a common teacher training program are official measures taken to ensure national educational standards.

There are a small number of private schools which provide education at all levels, from kindergarten to Form Six where students have to pay fees set by individual schools. Private schools must register with the Ministry of Education and follow the prescribed national curricula. They have their own final examinations for each level and often their students sit for national examinations as well.

The school year, which runs from the beginning of January to the end of November, is divided into two semesters. With so many cultures and religions in Malaysia, there are a number of occasions to celebrate and with these, come the holidays. Students have to come back for Saturday classes to make up the 190 school days, which is the minimum number of school days set by the Ministry of Education.

1.1.3 Malaysian primary education

As this study concerns the implementation of primary science curriculum, it is appropriate for the readers to have an overall picture of the primary education structure in order to gain an understanding of the role of science within the system.

There are two main categories of schools at the primary level. They are (i) the National Primary Schools referred to as SK or SRK where the medium of instruction is in Bahasa Malaysia, and (ii) the National-Type Primary Schools known as SRJK where the medium of instruction is either Chinese for SRJK(C) or Tamil for SRJK(T). Bahasa Malaysia and English are compulsory subjects in all schools. Chinese, Tamil and indigenous languages like Iban and Kadazan are also taught as Pupils' Own Language (POL) in national schools where there is a certain minimum number of pupils who wish to learn the language. However, this has to fall outside the school timetable.

The Integrated Primary School Curriculum, also known as Kurikulum Bersepadu Sekolah Rendah (KBSR), has been in force since 1983 and consists of two levels:
i. Level I for Primary 1 to Primary 3 and
ii. Level II for Primary 4 to Primary 6.

Subjects are assigned under three areas of study which include (i) Communication, (ii) The Universe and Man, and (iii) Self-development. Table 1.3 shows the allocation of subjects and the division of time per week for Level I and Level II in National and National-Type schools. Level I focuses on the acquisition of the basic skills of reading, writing and arithmetic. Living skills, Local Studies and Science are introduced at Level II.

Table 1.3: Structure of Malaysian Integrated Primary Curriculum (KBSR)

Areas of Study	Subject	Level I (Primary 1, 2, 3)		Level II (Primary 4, 5, 6)	
		SK	SRJK(C /T)	SK	SRJK(C /T)
1. Communication - Basic skills	Bahasa Malaysia	450	270	330	150
	Chinese / Tamil	-	450	-	300
	English	240	90[1]	210	90
	Mathematics	210	210	210	210
2. The Universe and Man - Spiritual - Values & Attitudes - Humanities & Environment	Moral Education / Islam [2]	180	180	180	180
	Science [3]	-	-	150	150
	Local Studies[3]	-	-	120	120
3. Self-development	Living Skills	-	-	60	60
	Health and Physical Education	60	60	60	60
	Music	60	60	60	60
	Art	60	60	60	60
Total teaching time		1260	1380	1440	1440
Co-curriculum		60	60	60	60

The number in each cell denotes the amount of time in minutes per week with one lesson making up 30 minutes. There is a 30 minute school assembly per week.

1 Primary one and two pupils from SRJK (C/T) do not take English until they reach primary three.
2 Muslim pupils attend Islamic Religious Studies while all other pupils attend Moral Education classes.
3 Science and Local Studies replace 'Man and His Environment' beginning December 1994.

Promotion from Primary One to Primary Six is automatic. The Education Act (1996) provides for a course of primary education designed for a duration of six years but this may be completed within five years. To identify pupils who are able to complete their primary education within five years, the Level One Assessment also known as Penilaian Tahap Satu (PTS) was introduced in 1996. PTS is administered jointly by the Examinations Syndicate and the school at the end of Primary Three. PTS is not compulsory and pupils can opt to sit or not to sit for it. Those with high scores are selected to go for double promotion to proceed to Primary Five. The selected pupils can still opt not to proceed to Primary Five if they choose. In 1998, 5,947 or 1.3% out of a total of 450,609 Primary Three pupils qualified for double promotion to Primary Five in 1999 (The Star, 12 October 1998). At the end of Primary Six, pupils sit for a national examination which is the Primary School Achievement Test also known as Ujian Prestasi Sekolah Rendah (UPSR). The subjects tested are Malay Language, English Language, and Mathematics. SRJK(C) pupils have to sit for test papers in Chinese Language while SRJK(T) pupils have to sit for test papers in Tamil Language. As of 1997, Science has also been included in UPSR for all pupils.

1.1.4 Overview of science education in Malaysia

The foundation for the development of the national education system rests on the National Philosophy of Education which states:

> Education in Malaysia is an on-going effort dedicated to developing the potential of individuals holistically in an integrated manner so that their development, based on the belief in God, is intellectually, spiritually, emotionally and physically balanced and harmonious. Such an effort is designed to produce Malaysians who are knowledgeable, possessing high moral standards and are responsible and capable of achieving a high level of personal well-being as well as being able to contribute to the harmony and betterment of the society and the nation at large.
>
> (Internet website: http://www.moe.gov.my/)

The overriding national objectives of education are national unity in a multi-ethnic society and human resource development to produce skilled manpower for national development. As science and technology has often been perceived as the driving force behind economic development in the industrialised countries, Malaysia like many developing countries, is investing heavily in science education in the hope of promoting economic development. On 28 February 1991, the Prime Minister of Malaysia delivered a working paper entitled “Malaysia: The Way Forward” at the first session of the Malaysian Trade Council (Prime Minister’s Department, 1991 cited in Syed Zin & Lewin, 1993). In this working paper, later to be commonly referred to as 'Vision 2020', nine basic strategic challenges are highlighted which have to be met to enable the country to achieve the status of an industrialised nation by the year 2020. The emphasis on science and technology has been reiterated in one of the challenges which states "the challenge of establishing a scientific and progressive society that is innovative and forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future" (Syed Zin & Lewin, 1993, p.1).

Malaysian science educators recognise the need for the science curriculum to keep in line with the international trends (Lee, 1992) if Malaysia were to achieve the vision of becoming a developed country by the year 2020. As Lee has described, curriculum developers make conscious efforts to emulate western science curricula with the help of foreign expertise. Current Malaysian primary and secondary science curricula have shifted the emphasis from acquisition of scientific knowledge by transmission to inquiry learning where pupils and students are to gain meaningful understanding of science concepts. This is seen as taking place through active physical and cognitive engagement in the learning process involving various science process skills, manipulative skills and thinking skills. Elements of science, technology and society such as the relevance of science to daily lives, and the relationships of science to the local environment and societal needs have also been included in the science curriculum documents.

The findings of studies carried out to investigate the existing status of classroom practice in science lessons in Malaysian schools had caused many educators and politicians to express their concerns over the availability of skilled manpower necessary to achieve Vision 2020. As shown in Table 1.4, the number of science stream students in upper secondary schools began to decline in the mid 1980s, with the proportion of science students falling from 29.5 per cent in 1986 to 20.78 per cent in 1991 (Syed Zin & Lewin, 1993). While the total number of students enrolled in upper secondary schools from 1981 to 1991 increased, the number of science students decreased. Syed Zin and Lewin also reported a continuing concern about the disappointing achievement levels for science for students at all levels. The Director-General of Education of Malaysia, in his opening address at the National Conference of Science Education (Ministry of Education, Malaysia, 1993b) expressed the urgency to determine the real reasons for the decline in students' interest and performance in science and rectify them before the problems got out of hand.

Table 1.4: Upper Secondary Enrolment in Malaysian Schools by Stream (1981 - 1991)

Stream	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Science	82192	74010	79947	88094	95843	99084	97293	94420	89366	84919	73904
%	30.37	28.85	26.24	27.14	29.32	29.5	27.73	26.28	24.92	23.49	20.78
Arts	169893	166476	206377	217436	211395	215674	230797	240803	242410	246370	251674
%	62.78	64.9	67.75	66.9	64.68	64.24	65.77	67.03	67.59	68.17	70.78
Vocational	13287	10861	12908	13551	13987	15295	17527	18846	21584	24845	24471
%	4.91	4.23	4.24	4.28	4.28	4.56	4.99	5.25	6.02	6.87	6.96
Technical	5234	5159	5338	5454	5614	5649	5292	5186	5248	5277	5261
%	1.93	2.01	1.77	1.68	1.72	1.68	1.51	1.44	1.46	1.46	1.48
Total	270606	256506	304620	324535	326839	335702	350909	359255	358608	361411	355580

(Source: Ministry of Education, Educational Statistics of Malaysia, 1981-1989, cited in Syed Zin & Lewin, 1993, p.24)

In response to this challenge, one of the resolutions adopted was to introduce the subject Science at primary level in the 1994/1995 school session which began in December 1994[1] . The decision was taken at a curriculum committee meeting on 29 May 1993 (circular 3/93 cited in Ministry of Education, Malaysia, 1997a). Implementation of KBSR in 1982 had phased out Science which was replaced by the subject 'Man and His Environment'. The latter was an integration of social science and science. With the reintroduction of science, at Level Two, science was introduced as a subject on its own with the allocation of five 30-minute lessons per week. However, at Level One, science elements were to be integrated into other subjects like the languages and Mathematics.

1.1.5 What does 'Education' mean to the Malaysian society?

In Malaysia, many parents see a university degree as the key to a better future. Their ultimate ambition in life is to provide their children with a university education. It is not uncommon to see poor parents slogging day and night supporting their children in the universities, sparing no effort to ensure that their children excel in education. Some parents go as far as to sell their land and houses, withdraw from their Employee

[1] In 1993, in an attempt to solve the problem of students unable to sit for the November public examinations due to the monsoon season in some states in the country, Malaysian Minstry of Education advanced the public examinations to October followed by about a month of holiday in November and the school year began in December. However, it was unable to solve the problem as the monsoon season seemed to have changed and in 1996, the school year reverted back to January.

Provident Fund and insurance or even borrow from the banks. They do not want their children to undergo the hardships they had endured. Except for the more fortunate who can afford to send their children abroad for their university education, the majority have to compete for the limited places available in the local universities. Non-Bumiputra[1] students have to do exceptionally well in their Higher School Certificate examination for admission into professional courses like medicine, engineering, law, pharmacy, dentistry and computing. The National Economic Policy reserves a certain quota for Bumiputra students. The popularity of these professional courses and the limited places are the main reasons for the stiff competition.

Many parents start looking for the 'right' schools at the primary level to give their children a good head start in their education. Both primary and secondary schools are judged by the performance of their students in the national examinations. Many teachers succumb to this pressure and try to do everything they can to ensure students do well in these examinations. Each time, upon announcement of the result of any national examination, newspapers are flooded with statistics comparing results between various states and schools. It is therefore not surprising that parents ferry their children from one tuition teacher to another during weekends and after school to make sure that the children get all the possible help to perform well in the examinations. Some parents pay large sums of money for their children to attend motivation seminars to help them to prepare for their forthcoming examinations like the UPSR. It was reported that one school paid as much as RM10,000 (equivalent to approximately NZ$5,000) for such a course held over a weekend (The Star, 2 February 1999).

1.2 Study Rationale

The new curriculum is now in the fourth year of implementation. The first group of pupils have sat for the UPSR science assessment at the end of 1997. Curriculum documents and supporting materials have been prepared and distributed, in-service orientation courses for teachers conducted, science rooms provided with the necessary equipment and materials. Studies done revealed various problems and constraints which impeded the successful implementation of the curriculum. There were reports of lack or total absence of inquiry learning in the science classrooms. The Sabah School Inspectorate Reports (Ministry of Education, Malaysia, 1995d, 1996e) revealed that science teachers were primarily using a didactic approach emphasising

[1] The Malays and all native ethnic groups are Bumiputra while the Chinese, Indians and other groups are non-Bumiputra.

delivery of knowledge and were not using an inquiry approach in their science teaching, as was advocated in the new curriculum. Equipment supplied were not used widely and teachers did not take the initiative to make use of readily available resources in their surroundings. A national survey conducted by the Educational Planning and Research Division (Ministry of Education, Malaysia, 1997a) reported that teachers were unable to implement the inquiry-based curriculum properly because they lacked the necessary science background knowledge, and they did not fully understand the content of the new curriculum and the various science teaching-learning strategies. Having been a primary science teacher educator for nearly 18 years, the researcher was concerned about the overall gloomy picture painted by these reports and decided that it would be worthwhile to study how experienced teachers implemented the new science curriculum in their classrooms. The findings of this study could provide a more in-depth understanding of the problems faced by the teachers than that provided by earlier surveys. This will enable the relevant authorities to take appropriate measures to rectify these problems.

1.3 Thesis Organisation

This thesis is organised into eight chapters. The introductory chapter sets the scene of the study by providing a background of the Malaysian education system focusing on primary education and an overview of science education. The rationale for the study is also described. Chapters Two and Three review the relevant literature on the development of science education and the various issues related to curriculum implementation respectively. Chapter Four describes the research methodology used in this study. It identifies the research questions and describes the methods used to seek answers to the research questions. The research participants, the research design, data collection techniques, the research procedure, ethical considerations, and data analysis are also described. Chapters Five and Six present the report on the case studies, focusing on the teachers' science teaching practices, their understandings of the Malaysian Primary Science Curriculum, and their conceptions of science and science teaching. Chapter Seven discusses the findings of the study across the five teachers, in relation to the research questions. Chapter Eight concludes by identifying the factors which affect the implementation of the Malaysian Primary Science Curriculum, followed by recommendations of actions to be taken. Suggestions for future research are also proposed.

CHAPTER TWO

DIRECTIONS IN SCIENCE EDUCATION

This chapter examines the historical development of understanding of the nature of science and of science learning over the last thirty years and how this has influenced the school science curriculum development. Contemporary issues related to science education such as content versus process, the constructivist approach to learning, learners' prior knowledge, learning as conceptual change, inquiry learning, 'hands-on' and 'minds-on' activities, situated learning, cognitive apprenticeship, and the relationships between science, technology and society are discussed. An overview of Malaysian Primary Science Curriculum is included to provide the readers with an understanding of the extent to which these issues have been addressed in the curriculum.

2.1 Views of the Nature of Science: Positivism, Post-Positivism and Constructivism

In the course of the seventeenth century, the realist perspective dominated the representation of scientific activity. Within realism, the world exists in an absolute sense, such that absolutely true discoveries could be made by unbiased observation and experimentation leading to the development of theories (Chalmers, 1982). The high status of natural science research has been linked to its success and to its perceived objectivity, wherein the scientist was seen as a rational spectator (Toulmin, 1981). Universal statements or concepts were thought to be obtained by inductive generalisation from a suitably large number of diverse singular statements (Gilbert & Watts, 1983). The mind was a blank tablet to be written on by experience (Strike & Posner, 1982). Scientific knowledge was understood to exist in the world to be confirmed or refuted by an empirically based search. This empirical-inductivism philosophy as espoused by Bacon, Locke and Hume supported the advance of science. This notion of science which put ultimate faith in observation and empiricism, was also called positivism in which science was seen as an accumulation of all that had been learned over history, each new law adding its weight to the mass of science. The end of the nineteenth century found scientists engaging in the development of many enormously abstract theoretical positions such as evolution, natural selection, thermodynamics, kinetic-molecular theory, existence of the atom, and the physics of atomic particles. The objective was to develop one singular form for judging all theoretical statements in science. Crucial elements of this form were empirical observations and logic. Logical positivism and logical empiricism were based upon this reliance on empiricism and logic.

The grip of logical positivism and empiricism on the philosophy of science was weakened by the arguments of individuals such as Kuhn, Lakatos, Toulmin and Popper. Kuhn's (1970) "Structure of Scientific Revolutions" advanced the idea that 'normal' science was the work done under the guidance of a paradigm and 'revolutionary' science as those rare creative productions when a new explanatory paradigm was advanced and a new course of normal science began. Toulmin (1972) pointed out that several alternative and competing theories existed and suggested the idea of 'evolutionary' science, where old ideas were gradually modified and new ideas gradually evolved. These together with Popper's (1972) "falsificationist doctrine", Lakatos' (1970) "research programs", and Feyeraband's (1979) argument "against method" caused questions to be asked about the objectivity of the positivist science, and the fallibility of science was highlighted. Despite many points of disagreement, these alternative perspectives shared in the view of the theory-ladenness of observation, the evolutionary approach to theory building, and in the provisional nature of scientific knowledge.

In recent years, philosophers of science concerned with knowledge production, have moved away from the empiricist and positivist views that centred on experiments designed for proof of falsification of hypotheses to establish 'truth' and towards constructivist views. Constructivist views centre attention on the construction of explanatory models that encompass increasingly wider ranges of phenomena, that is, models that are robust and parsimonious (Novak, 1988). Constructivists believe in a carefully constructed understanding of the world through which people interpret their experiences and reject the idea that an objective collection of data exists (Benson, 1989).

Von Glasersfeld (1984) described two extreme views of the nature of knowledge, known as metaphysical realism and radical constructivism. These two views correspond to what Phillips (1995) described as "nature the instructor versus humans the creators" (p.7). The metaphysical realism view or "nature the instructor" corresponds to the positivist view described earlier in this section. According to Staver (1995), metaphysical realists assume the existence of an external world which is separate from human perception, and they view knowledge as a correspondence with an external world that is directly knowable. To the realists, "knowledge is knowledge of the external world, and improving knowledge means improving its match with the structure of the external world" (Staver, p. 1126). The realists maintain that there is a definite, knowable reality out there and humans strive ever more closely to know it.

Radical constructivism or “humans as creators” defines knowledge as functionally adaptive cognitive structures that knowers construct. Radical constructivists are often misinterpreted as not acknowledging the existence of an external world at all possibly because they make no a priori assumption about the existence of an external world or its existence apart from human perception (Staver, 1995). According to Staver, radical constructivists, in fact, do acknowledge that there is an external world, only that external world is not directly knowable. In this way, radical constructivism denies the possibility of any certain knowledge of the reality of the external world and considers the pursuit of ultimate truth as illusory as the world is never fully knowable (Novak, 1993). Therefore, a constructivist view of knowledge needs not imply relativism and a realist position can be adopted. The charge that the constructivist position results in relative knowledge is only true if socially determined ideas are presumed to be invalid (Benson, 1989).

The criticism aimed at Von Glasersfeld's radical constructivism is the focus given to the solitary experiences of the knowing individual while undermining the social construction of consensual ideas. Von Glasersfeld's constructivism reduces all understanding, including that of science, to making personal sense of the world (Bliss, 1995). This leads to the argument that as our personal world is created by the mind, no one world is any more real than any other. Thus the students' ideas are not to be considered wrong when compared with the accepted ones of science, but only different. It is even argued that the children's ideas should be given the same deference and respect that one would give to scientific theories (Solomon, 1994). Solomon opposed this argument strongly, and insisted that, "personal knowing is notoriously precarious and subject to brain-washing, unless socially reinforced" (p.15). Solomon differentiated the processes of socialisation in the domain of science and in that of the life world. She argued that science has been built up into a knowledge system by a consensual process which is not that of the life world. Scientific knowledge is the result of a long apprenticeship of learning definitions, solving problems in accepted ways, and studying papers in the chosen field of knowledge (Ziman, 1968). Driver, Asoko, Leach, Mortimer, and Scott (1994) saw this in the same light when they argued that scientific knowledge as public knowledge is constructed and communicated through the cultural and social institutions of science as a result of considerable intellectual struggles before it becomes part of the taken-for-granted way of seeing things.

Furthermore, a view of scientific knowledge as socially constructed does not logically imply relativism. Harre (1986) suggested that scientific knowledge is constrained by how the world is and that scientific progress has an empirical basis, even though it is socially constructed and validated. It is unlikely that individuals through their own empirical enquiry will discover the scientific entities and ideas which are constructed, validated and communicated through the cultural institutions of science (Driver et al.,1994). As Solomon (1994) put it more bluntly, "Changes to theory do occur, but they are certainly not brought about by school pupils who have difficulty in comprehending science textbooks" (p.16). While identifying good points about constructivism, Phillips (1995) summed up the weakness of constructivism as "the tendency within many forms of constructivist epistemology towards relativism, or towards treating the justification of our knowledge as being entirely a matter of socio-political processes or consensus, or towards the jettisoning of any substantial rational justification or warrant at all" (p.11).

Thus, science has come a long way from the philosophical foundation of positivism of 'modern science' based on the rational investigation of the physical world in the early seventeenth century to the 'post-modern science' which portrayed the image of science as an enterprise that goes on essentially within nature, not outside it (Toulmin, 1981). The common threads that emerge from the new philosophy of science are:

1. Scientific knowledge is tentative and provisional. It cannot be equated with truth.
2. Observation alone cannot give rise to scientific knowledge in a simple inductivist manner. Scientists study a world of which they are a part, not a world from which they are apart.
3. Scientific knowledge is personally and socially constructed.

2.2 School Science Curriculum Development

The history of school science education is a recurrent cycle of periods in which the methods of science have been strongly emphasised in curriculum rhetoric, interspersed with periods when content features more predominantly (Millar & Driver, 1987). Until the 1950s, science teaching was essentially knowledge-based, with the transmission of the content of science to the passive learners who were supposed to build up the fabric of their scientific knowledge slowly and methodically. The role of the processes of science was not acknowledged explicitly in the curriculum (Cleminson, 1990).

The launching of Sputnik in 1957 by the Soviet Union was seen as a failure in the Western traditional science teaching. The tentative nature of scientific knowledge, the information explosion, and the development of cognitive psychology rendered positivist and behaviourist traditional methods of science teaching unattractive. A shift began to move towards a 'process approach'. The process approach appealed to the science educators as it was seen to advocate progressive teaching methods focusing on child-centred and discovery learning methods (Millar & Driver, 1987). Content was not considered important, as the consensus on what constitutes valid knowledge for the science curriculum was ever changing, while the methods of science were unchanging and independent of content (Osborne & Simon, 1996).

The acquisition of particular conceptual knowledge was seen as less important than understanding and developing the skills and techniques of scientific inquiry (Hodson, 1996). Earlier, Gagne (1965) described processes as skills used by all scientists which were applicable to investigation in all the sciences, and could be transferred across content domains. Therefore, it was essential for an individual to know the processes of science before he could understand science. Piagetian cognitive developmental stages and Armstrong's heuristic approach further supported the kind of developments that initiated the process-led science curriculum in the 1960s and 1970s. Schwab (1962) proposed a model of scientific inquiry as the best way of learning science. There seemed to be agreement that the best way to learn science was for students to be doing science, carrying out the scientific inquiry similar to that used by the scientists. Subsequently, much of the innovative science curricula was process-oriented, aimed at providing students with general inquiry or problem-solving skills. Correct performance of the 'scientific method' became an end in and of itself (Smith & Neale, 1989). It was assumed that content knowledge and conceptual understanding would follow naturally from a correct application of the inquiry process (Prawat, 1992).

As a result of these developments, huge investment was poured into large scale curriculum development in secondary school science education (Bliss, 1995). In the USA, there were projects such as the Physical Science Study Committee (PSSC), the Chemical Bond Approach (CBA), ChemStudy, and Biological Sciences Curriculum Studies (BSCS). England followed with a number of science curriculum development projects sponsored by the Nuffield Foundation in Physics, Chemistry, Biology and Integrated Science. Other countries such as France, Germany, Sweden, Canada and Australia followed, some adapting the ideas and others developing their own. Much of the curriculum reform that took place during the 1960s and 1970s in Asia and Africa were oriented towards the adaptation of what was thought to be good practice in Western countries (Lee, 1992). For example, the Scottish Integrated Science course was adopted in West Indies, Botswana, Lesotho, Swaziland, Nigeria, and

Malaysia (Wilson, 1981). Professional expertise and financial aid were offered to Third World countries to initiate school science curriculum reforms through various organisations in the Western countries such as UNESCO, British Council, and ODM (Overseas Development Ministry).

Malaysian school science curricula had strong British influence as Malaysia was once a British colony and its educational system was a colonial legacy in terms of its structure, curriculum, and examination policies (Lee, 1992). In the 1970s, several science curriculum programs from the United Kingdom had been modified and adapted for use in Malaysian schools. The Integrated Science course, introduced in 1969, for Form I, II and III students, was a modification of the Scottish Integrated Science Syllabus. The Modern Physics, Chemistry and Biology courses, which were two-year courses for science students in Form Four and Five, were adapted from Nuffield O-level courses in 1972. At the same time, the Arts students were following the Modern Science course which was adopted from the Nuffield Secondary Science. Continuity, feasibility, and relevance were attributed as the reasons why Malaysia adopted the Scottish Integrated Science and the Nuffield Science curricula (Zainal, 1988, cited in Lee, 1992).

Until the 1950s, the study of science in primary schools was essentially restricted to nature study with the development of love of nature as the main aim (Layton, 1973). According to Layton, training in observation was the only intellectual development as an objective for science teaching. In the 1960s and 70s, primary science education saw parallel developments in USA and UK to those in secondary science education. A series of process-based projects arose, among which in the USA, there were Science A Process Approach (SAPA) developed by the American Association for the Advancement of Science (AAAS, 1967), Elementary Science Study (ESS) published in 1967 and the Science Curriculum Improvement Study (SCIS) published in 1969. In Britiain, there were the Oxford Primary Science Project (Redman, Brereton, & Boyers, 1969), Nuffield Junior Science (Wastnedge et al., 1967), Schools Council Science 5-13 project, Warwick Science Process (Screen, 1988), and Match and Mismatch (Harlen, Darwin, & Murphy, 1977). These projects were influenced heavily by Piaget, that is, that primary age children can only learn efficiently from concrete situations and that children have a natural urge to explore and discover. The content of science curricula was to be matched to children's level of intellectual development. These curricula could be collectively described as reflecting a 'process approach', where children were to mimic the scientific inquiry of scientists, giving prominence to the processes by which scientific knowledge was acquired. It was argued that primary science education should therefore be a process of learning by discovery with emphasis on learning to do science rather than learning about science.

However, there was difference in the degree of emphasis of process over content. For example, SAPA, Nuffield Junior Science and Warwick Science Process used a highly structured approach to teach specific processes of science, with materials structured under process headings such as observing, classifying and predicting. ESS emphasised independent exploration of phenomena while others like SCIS attempted to develop some understanding of science concepts as well as an open inquiring mind (Osborne & Simon, 1996).

2.3 Contemporary Issues in Science Education

2.3.1 Content and process reconsidered

The disparate views about the aims of science education, with some emphasising the development of scientific skills and attitudes and others the development of scientific knowledge, have been present since the introduction of science to elementary schools and remain at the core of the debate about the nature of science to be taught in primary schools today (Osborne & Simon, 1996).

In recent years, constructivism has given rise to dispute about the apparent irrationalism and associated relativism of science in science education (Driver et al, 1994). While the dispute continued on the worthiness and validity of the scientific knowledge and the scientific methods, there seemed to be general consensus that scientific knowledge is worthy knowledge and that understanding of basic scientific knowledge should be an important component in science education. Schools in England and Wales have now arrived at a position where primary science is compulsory with a prescriptive content, and a weighting of 60% was given to content in its assessment at age 11 (Osborne & Simon, 1996). Scientific knowledge was viewed as more than personally held belief reinforced by personally gathered observation confirmation (Hodson, 1996). A view of scientific knowledge as socially constructed did not logically imply relativism as scientific knowledge was constrained by how the world was and that scientific progress had an empirical basis (Driver et al, 1994). Scientific knowledge has been subjected to, and has survived, critical scrutiny by members of the scientific community, using whatever methods and criteria deemed appropriate to ensure the necessary degree of validity and reliability (Driver, 1989; Hodson, 1996). Hodson considered science as an attempt to explain and account for the real nature of the physical universe regardless of whether it made sense in the everyday meaning of that expression. He described learning science as an introduction into the world of concepts, ideas, models, conventions, procedures, and theories that scientists have developed and accumulated. Driver (1989) argued that as science ideas were constructed and transmitted through the culture and social institutions of science, it was unlikely that these ideas would be discovered by individuals through their own empirical enquiry. Learning science involved being initiated into the culture of science. Therefore, one important goal of science education is concerned with students' understanding and mastery of the coherent bodies of organised scientific knowledge.

Miller and Driver (1987), and Hodson (1992) argued strongly against content-free process-based science curriculum. Millar and Driver regarded processes which were commonly identified as scientific, as characteristics of many human endeavours and therefore did not characterise the pursuit of science. Processes were theory-impregnated and what children noticed and did, and the interpretations they gave, depend on the conceptions they used (Hodson, 1992, 1996) . Scientific observation, scientific classification and scientific hypothesising rather than observation, classification and hypothesising *per se* were appropriate to be taught in science lessons. The processes only became scientific when they utilise scientifically significant content and embody scientific purpose. "Science does have methods, but the precise nature of those methods depends on the particular circumstances: on the matter under consideration, on whatever existing theoretical knowledge is considered applicable, and on the investigative techniques and instrumentation devices currently available" (Hodson, 1992, p. 131).

> In recent years, a consensus appears to be developing. ... On this view, processes, generalisations, and concepts are all seen as important criteria for the selection of activities. Within this overall stance, process criteria is still as important but not nearly to the same degrees as in the orthodoxy of ten years ago.
>
> (Richards, 1983, p.6)

The above statement continues to reflect the existing status of contemporary science education. It is argued that science education should support students to engage in processes such as scientific observation, scientific classification, and scientific hypothesising to gain meaningful conceptual understanding of scientific knowledge. This would seem to indicate that processes are the means and the content is the product. However, it is the contention of the author that from the constructivist perspective, neither content nor process should be seen as the end products. Processes are used as pedagogic means to pursue scientific knowledge which will form the theoretical understandings in the pursuit of new knowledge. They are the devices a teacher uses to engage children's minds and encourage their thoughtful participation enabling children to develop meaningful understanding of scientific concepts. These then become effective conceptual tools to construct more new knowledge. Science is characterised by its concepts and purposes, not by its methods (Miller & Driver, 1987).

The formal learning of science in schools ought to involve not only gaining an acquaintance with the phenomena of the natural world, it should also involve learning about the theoretical entities which have become accepted within the scientific community (Driver & Erickson, 1983). Science knowledge is socially constructed, and mediated in a research tradition commonly shared by scientists (Cheung & Taylor, 1991). This social character of science results in certain legitimate world views about the nature of scientific methodology, patterns of scientific change, status of scientific knowledge and its demarcation from non-science. Since scientific knowledge is a product of human corporate endeavour, pupils need to be initiated into this common social-constructed world during their personal construction of knowledge. It is in this research tradition that the objectivity of scientific knowledge can be defined. Hence, theories should be viewed as provisional and fallible. Science knowledge is constructed in an objective way, deploying scientific process and problem-solving skills and science concepts in a relevant context. This construction process is guided by the specific habits of the mind and prior conceptions of students, allowing them to make claims about what they value, believe, or feel, and also about how they perceive the way the world works.

Science knowledge has to be both personally and socially constructed. The science curriculum, rather than being considered as that which is to be learned, is seen as a set of experiences from which the learners construct a view closer to the scientists' view (Driver, 1989). As a mediator between the scientists' knowledge and children's understanding, the teacher is required to act as a diagnostician of children's thinking and at the same time to carry a map in his or her head of the conceptual domain which enables appropriate activities to be suggested and meaning negotiated. The process of negotiation of meanings between teachers and pupils is the key characteristic of the constructivist pedagogy.

2.3.2 Constructivist view of learning

Contemporary perspectives on cognition and learning reject the view that learning is a one-way process whereby the learner receives and organises stimuli from an external world. Instead learning from a constructivist perspective is viewed as an active process in which the learner's prior knowledge is *a sine qua non* in constructing meaning and that the interaction between new knowledge and existing relevant knowledge of the learner is the most important ingredient. Learning is viewed as a purposeful and relevant process of meaning construction, linked to the values, beliefs and attitudes pupils hold, and the meanings they construe in the problem context (Cheung & Taylor, 1991). The traditional passive telling-listening relationship between teacher and student is replaced by one that is more complex and interactive in all constructivist teaching-learning scenerios (Prawat, 1992). Prawat described students' cognition and sense making as the defining feature of the constructivist approach. Learning is seen as conceptual change, the restructuring of existing ideas and construction and acceptance of new ideas. New knowledge has to be firmly anchored to existing knowledge, and interactions between existing knowledge, the ideas of others, and experiences can lead to existing ideas modified, extended or changed in the process. This also implies that learners are responsible for their own learning in that they have to direct their attention to the learning task, and draw on their present knowledge to construct meaning for themselves (Driver & Bell, 1986).

This has strong implications in science education. Students come to science lessons with their own ideas about phenomena, meanings for words and explanation of why things behave the way they do. It is no longer feasible to think of learning as filling students' blank minds or empty heads with scientific ideas. Learning science is about students developing or changing their existing ideas to resemble more closely scientists' ideas. "Learning science is not simply a matter of making sense of the world in whatever terms and for whatever reasons satisfy the learner. Learning science involves an introduction into the world of concepts, ideas, understandings and theories that scientists have developed and accumulated" (Hodson, 1996, p.127). The function of teaching and learning science has shifted from providing students with new scientific concepts and ideas, to one where students have ideas and concepts which must be challenged and reconstructed anew. The process of teaching requires students' existing ideas to be elicited, then challenged and modified, rather than developed anew.

2.3.3 Learners' prior knowledge

Studies have shown that children bring along notions about the physical world that develop apart from formal schooling which are not in accord with the way that these phenomena are interpreted in school science (Driver & Erickson, 1983). These children's ideas and beliefs have been given labels like "preconceptions" (Ausubel, 1968), "alternative frameworks" (Driver & Easley, 1978), "alternative conceptions" (Osborne & Gilbert, 1980), "children science" (Osborne & Bell, 1983), and "misconceptions" (Helm, 1980). Students' ideas on various topics have been explored using techniques like Interview-about-Instances (Osborne & Gilbert, 1980); Concept Maps (Novak & Gowin, 1984); Context Maps (Bloom, 1995); and Predict-Observe-Explanation (Champagne, Klopfer, & Anderson, 1980). Children's conceptions of physical phenomena have been documented in a wide range of science domains such as energy, heat and temperature, gravity, electricity, plants and animals, chemical change, light and other areas (Driver & Erickson, 1983; Gilbert & Watts, 1983). Pfundt and Duit (1991) compiled a bibliography of over two thousand similar studies. White (1992) reported studies of misconceptions of various science concepts by students in different countries and at different levels of schooling. Driver and Bell (1986) reported that even though there were cases where children had idiosyncratic ideas and beliefs, there were common and identifiable features in many of the children's ideas and beliefs. Within particular science domains, there are commonly occurring informal ways of modelling and interpreting phenomena that are found among children from different countries, languages and education systems (Driver et al., 1994).

These alternative beliefs are found to be resistant to change and they seem to persist despite students' exposure to the scientists' conceptions (Driver & Bell, 1986; White & Mitchell, 1994). Studies have shown that instructional efforts only directed at teaching the scientific concepts are not sufficient to modify in a positive way the conceptual frameworks of most students (Novak, 1988). Some students learn to play the 'school game' of rote learning and the regurgitation of curricular knowledge while some students simply hate and refuse to learn knowledge which they see as meaningless, irrelevant and useless information that has nothing to do with the real world in which they live in (Pines & West, 1986). According to White and Mitchell, very often, there is no genuine effort on the part of the students to make personal sense of the knowledge imposed or to resolve any contradictions that arise.

In conventional instruction, learners often follow a path that Perkins (1991) referred to as "conflict buried". Here the teachers completely ignore the conflict between the learners' naive models and the target model. Ignoring or inadequate consideration of student's prior conceptions often leads to undesirable consequences such as (i) the student's view is unchanged by science teaching, (ii) the student has two views for the same idea, one being a scientific view for school and examination purposes and an original view which remains unchanged, and (iii) an amalgam of the learner's view and the teacher's view (Gilbert, Osborne, & Fensham, 1982). Cleminson (1990) described an even worse scenario where students' ideas sometimes become less congruent with scientific ones as a result of the science lessons. Taking seriously into consideration learner's prior conception is necessary to achieve the desired outcome of science education, which is the development of learners' science to resemble more closely the scientists' science. Learning is thus seen as involving a process of conceptual change.

2.3.4 Learning as conceptual change

Pines and West (1986) used the terms conceptual resolution, conceptual development and conceptual exchange to refer to the conceptual change process depending on the degree of congruency or conflict between learner's existing knowledge and the new knowledge. Carlsen (1991) used the terms assimilation and accommodation to describe these cognitive changes. According to him, assimilation occurs when learners are able to incorporate new knowledge into their old knowledge using their existing concepts, while accommodation occurs when learners are unable to incorporate new knowledge into old cognitive structures and the old beliefs have to be replaced or reorganised.

Posner, Strike, Hewson, and Gertzog (1982) proposed a general theory of accommodation. They described the cognitive requirements for conceptual change as intelligibility, dissatisfaction, plausibility and fruitfulness. They argued that learners would change their existing ideas and accept new ideas when they are dissatisfied with their existing idea and find the new proposition as intelligible, plausible and fruitful. Smith and Neale's (1989) strategies are very similar. They identified the following as crucial to success in bringing about significant conceptual change in students' ideas: (a) eliciting students' preconceptions and predictions about phenomena, (b) asking for clarification and explanation, (c) providing discrepant events, (d) encouraging debate and discussion about evidence, and (e) clearly presenting alternative scientific explanations.

Various models have been developed to facilitate the process of conceptual change. These include the following:

1. The Children's Learning in Science Project (Driver & Oldham, 1986) which uses a five-phase teaching sequence consisting of orientation, elicitation of ideas, restructuring of ideas, application of ideas, and reviewing the change in ideas.
2. The Generative Learning Model (Osborne & Wittrock, 1985) which has three distinctive phases: the focus phase, the challenge phase, and the application phase.

3. The Concept Learning Model (Nussbaum & Novick, 1982), where concept learning is achieved by exposing alternative framework, creating conceptual conflict, and encouraging cognitive accommodation.
4. The Interactive Teaching Approach (Biddulph & Osborne, 1984) which consists of five key components involving preparation, exploration, children's questions, specific investigations and reflection.

Essentially these teaching approaches consist of the processes of exploring, developing and modifying students' ideas. They involve strategies which

(i) encourage students to make their ideas explicit;
(ii) present students with activities which challenge their ideas;
(iii) provide opportunities for students to generate alternative views including the scientists' views; and
(iv) provide opportunities for students to use the scientific ideas in a wide range of situations.

Based on this perspective, learning science involves both personal and social processes (Driver et al., 1994). The individual process involves providing learners with physical experiences that induce cognitive conflict and hence encourage learners to modify their existing schemes to develop new knowledge schemes that are closer to scientific views. According to Driver et al., practical activities supported by group discussions form the core of such pedagogical practices. The learners are confronted with situations that make the inherent inconsistencies in the learners' naive model plain and challenge the learners either to construct better models or to ponder the merits of alternative models presented by the teacher (Posner et al, 1982). Cheung and Taylor (1991) suggested the development of methods of group dialogue that allows the achievement of group consensus to facilitate the crossing from the learners' personal knowledge to the domain of socially justified and publicly mediated scientific knowledge. They described the role of the teacher as both the diagnostician and the mediator between personal (student's) and public (scientist's) knowledge. Teachers are to provide the learners with appropriate experiential learning activities. Teachers are also responsible for creating a classroom atmosphere within which teachers and students can interact positively with each other and where individuals' meanings are listened to and respectfully questioned. Thus, social interaction in groups is seen to provide the stimulus of differing perspectives on which individuals can reflect (Driver et al.). Head (1986) suggested that a supportive classroom climate is essential for constructivist learning, whereby students are encouraged to express their ideas, one in which incorrect ideas are treated as informative and potentially useful rather than merely the subject of criticism.

This conflict faced path as described above, requires learners to compare and contrast an entrenched but barely articulated model with a unfamiliar, newly sketched scientific model (Perkins, 1991). According to Perkins, this places extremely high cognitive demand on the learners and has resulted in them having difficulty with this path. Perkins suggested a "conflict deferred" path where the learners would learn the new scientific way of thinking and talking about the phenomena. Only after the new way has become somewhat familiar and consolidated, then the instruction turns back to the naive model and the relationship between the naive model and the new model is explored. As familiarity with the new model would reduce the learners' cognitive load, it would be worthwhile to conduct further research in this area.

2.3.5 Inquiry learning

Schwab (1962) drew upon the distinction between (i) 'teaching science' by inquiry and (ii) teaching 'science as inquiry'. Teaching and learning science by inquiry refers to the activities of students in which they develop knowledge and understanding of scientific ideas. According to Tamir (1985), teaching and learning by inquiry is congruent with Piagetian psychology, as well as with recent views of cognitive science, which argue that concepts, principles and facts are constructed by the learner rather than transmitted and absorbed as verbal knowledge. Inquiry enables the learner to engage in construction of concepts from experience and from verbal interaction. Student inquiry in the science classroom encompasses a range of activities. Some activities provide a basis for observation, data collection, reflection, and analysis of first-hand events and phenomena. Other activities encourage the critical analysis of secondary sources including media, books and journals. The role of the teachers is to guide, focus, challenge, and encourage student learning at all stages of inquiry.

'Science as inquiry' has been described as the substantive focus of the classroom which determined what is taught and hopefully learned (Schwab, 1963 cited in Tamir, 1990). According to Schwab, the essence of teaching 'science as inquiry' would be to show some of the conclusions of science in the framework of the way they arose and were tested. As students learn currently accepted scientific theories, principles, concepts and facts, they need to be aware of the nature of scientific inquiry which gives rise to the tentative structure of scientific knowledge (Welch, Klopfer, Aikenhead, & Robinson, 1981). This is to ensure that the students develop a realistic image of science, i.e. scientific knowledge is always open to change and revision where changes come about in the ongoing process of inquiry rather than to be viewed as a collection of facts that constitute a body of literal and absolute truth (Tamir, 1985).

As teaching science by inquiry enhances meaningful learning and teaching science as inquiry helps to develop a realistic image of science, it is desirable that students should be engaged in learning 'science as inquiry' by inquiry. Schwab (1962) argued that science as inquiry should be given the first priority as the objective of science teaching over that of teaching science by inquiry. In the United States, this is reflected in the National Science Education Standards (National Research Council, 1996) where science as inquiry has been included as one of the eight categories of content standards. Here, science as inquiry is described as the basic to science education and a controlling principle in the ultimate organisation and selection of students' activities. Students are required to combine processes and scientific knowledge to develop their understanding of science. This can be achieved by engaging them actively in scientific inquiry, thus enabling them to develop their abilities to do scientific inquiry and to enrich their understanding about scientific inquiry.

There has been an emphasis on inquiry in science education during the past two to three decades as evidenced in science curriculum reform throughout the world. Costenson and Lawson (1986) reported the results of the meta-analysis of 302 studies which showed that all of the inquiry-oriented curricula proved superior to traditional curricula across all measures of performance. However, the desired degree of inquiry instruction in the classrooms is rare. The greatest barrier to the teacher support of inquiry seems to be its perceived difficulty. Teachers are confused over the meaning of inquiry in the classroom. There are concerns over discipline, lack of time, inadequate equipment and materials, suitability for students, and there is worry about teachers' allegiance to teaching facts and about adequately preparing children for the next level of education (Welch et al, 1981; Costenson & Lawson). Costenson and Lawson argued that these reasons were not valid enough for not using inquiry. According to them, teachers with proper understanding and skills in inquiry teaching techniques together with sufficient subject matter knowledge should be able to use inquiry teaching in their classrooms. Tamir (1990) recognised that at the initial stage, careful preparation would take a lot of time in planning for inquiry teaching but eventually, as teachers became more familiar with the meaning of inquiry learning, the planning required no extra time in preparation.

2.3.6 'Hands-on' and 'minds-on' activities

The fundamental assumption behind the hands-on activities is that the use of concrete and realistic experiences will enhance active participation of students in the meaning making process. Children learn science by doing things, doing them both in the hand

and in the head (Millar & Driver, 1987). For primary school children, the concrete and realistic experiences should be coupled with active cognitive participation to facilitate the modification of their existing ideas to resemble more closely to those of the scientific ideas. In other words, hands-on activities must go hand in hand with minds-on experiences to ensure meaningful learning.

No one method of instruction, in and of itself, is better than others (Miles & Deventer, 1986, cited in Hodson, 1993). The most appropriate teaching style depends on the particular goal that is being sought. Therefore, it is obvious that understanding and acquisition of a wide range of scientific concepts, skills and attitudes can only be achieved by employing a wide range of learning experiences. Experiments, demonstrations and field trips which provide first hand experiences for students, are particularly suitable for elementary students who are in their concrete operation stage of development. Resources such as books, magazines, films, slides, videos, and computer programs, provide information on a wide range of topics and are particularly valuable for those topics where primary materials are inaccessible to the students. Simulations, role play, games, quizzes, teacher explanations, analogies, concept mappings, and discussions all have their important role in the conceptual change learning process.

The success of any method of instruction in bringing about students' conceptual understanding does not depend on the labels attached to these methods. It depends on what the teacher does to create the appropriate student-teacher and student-student interaction involved in these strategies. Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry (National Research Council, 1996). A laboratory exercise may just be an experience of following cookbook instructions which result in rote learning. Textbook presentation or a teacher's lecture needs not be a means for indoctrination but, instead, can be an effective way of presenting science as inquiry (Tamir, 1985). The key to teaching with understanding is verbal interaction that enables teachers to monitor students' understanding of science concepts and the quality of the teachers' questions (Tobin, Tippins, & Gallard, 1994). One of the most critical factors in exemplary teaching practice is the ability of the teacher to monitor students' understandings and to react when there is misunderstanding, to pose questions to students that stimulate thinking in particular directions, and to prompt extensions of their thinking (Tobin & Fraser, 1990 cited in Pressley & McCormick, 1995). Harlen (1992) described science sessions which were all practical activity to the neglect of discussion and reflection as unsatisfactory as learning experiences in lessons which were all talk and no practical activity.

Roychoudhury (1994) described a teacher using hands-on activities where students simply followed instructions and the teacher provided them with an explanation of what they were supposed to do and observe, as well as summarising the specific concepts which they were supposed to grasp. Here, the students were never given the opportunity to explore beyond what was given within the structure of the lessons. According to Roychoudhury, activities carried out in this manner "became a mere conveyor of ideas from the teacher to students instead of a progenitor of thoughts and modifications of students' existing knowledge" (p.94). Other studies also showed a similar lack of effectiveness in laboratory instruction where students were confined to lower-level skills (Lunetta & Tamir, 1979; Solomon, 1992; Stake & Easley, 1978). Teachers often tell students just about everything from about how to assemble an apparatus, how to design an experiment, to what outcome to expect (Raghubir, 1979; Ramsden, 1992). Solomon reported that active participation is confined to the manipulation of objects, while the thinking processes behind the activities leading to the modification of existing ideas is very much lacking. Simply allowing students to put their hands on science equipment and manipulate them is fruitless unless the experience is directed by the brain (Brandwein & Glass, 1991).

2.3.7 Situated learning

Situated learning emphasises the idea that much of what is learned is specific to the situation in which it is learned, and that many skills are best taught in the context of their application to real world problems or concerns (Prawat, 1992). Learning difficulties in the classrooms have often been attributed to the mismatch between typical classroom situations and real world situations. This makes a strong case for changing classroom activities to resemble more closely those of real life situations, thus creating more opportunities for students to engage in authentic activities in the classroom (Brown, Collins, & Duguid, 1989). In fact, authentic tasks are being suggested as an important criterion for restructuring schools. Jonassen (1991) defined authentic tasks as those that have real world relevance and utility, that integrate those tasks across the curriculum, that provide appropriate levels of complexity, and that allow students to select appropriate levels of difficulty or involvement.

Blumenfeld (1992) suggested that the use of cognitive tools, multiple sources of information, and other individuals as resources, are conditions that approximate everyday learning. Collins, Brown, and Newman (1989) suggested that situated learning could foster learning by encouraging learners to carry out tasks and solve problems in an environment that reflected the multiple uses to which their knowledge would be put to use in the future. According to Collins et al., by actively using knowledge rather than passively receiving it, the learners can better understand and appreciate the purposes of the knowledge they are learning. Moreover, learning in multiple contexts induces knowledge abstraction resulting in learners acquiring knowledge in a dual form, both tied to the contexts of its uses and independent of any particular context. Blumenfeld was of the opinion that deep, rather than superficial learning would occur when learners had the opportunity to grapple with authentic and complex problems, under conditions that approximate everyday learning.

Anderson, Reder, and Simon (1996) described the four central claims of situated learning with respect to education as: (i) action is grounded in the concrete situation in which it occurs; (ii) knowledge does not transfer between tasks; (iii) training by abstraction is of little use; and (iv) instruction must be done in complex, social environments. They argued that these claims have been overstated and that some of the educational implications that had been taken from these claims were misguided. According to them, "while cognition is partly context-dependent, it is also partly context-independent; while there are dramatic failures of transfer, there are also dramatic success; while concrete instruction helps; abstract instruction also helps; while some performances benefit from training in social context, others do not." (p.10). Though they have critiqued the generalizability of the situated learning claims, they could not deny the successes that situated learning has brought about. Indeed, studies have shown that learning is most successful when embedded in authentic and meaningful activity, making deliberate use of the physical and social context (Hennessy, 1993). The importance of situated learning has been emphasised in contemporary science curricula internationally. Relevance to students' daily lives, relating to students' environments, interests and needs, cultural and gender issues have been included in these curricula.

2.3.8 Cognitive apprenticeship

Cognitive apprenticeship is the notion of the craft apprenticeship methods being adapted for the teaching and learning of cognitive skills in a classroom context. Studies show that cognitive apprenticeship have been successfully used in teaching students the thinking and problem-solving skills in various school subjects. Three success models included "reciprocal teaching of reading" (Palinscar & Brown, 1984), "procedural facilitation in writing" (Scardamalia, Bereiter, & Steinbach, 1984), and "mathematical problem solving" (Schoenfeld, 1983 cited in Collins et al., 1989). According to Collins et al, these three models are based on explicit formulations of cognitive and metacognitive strategies and the teaching is centred around activities designed to convey these explicitly to the learners.

Collins et al. (1989) described modelling, coaching, scaffolding, articulation, reflection and exploration as the components of cognitive apprenticeship. Modelling, coaching, and scaffolding are considered as the core of cognitive apprenticeship designed to help learners acquire an integrated set of skills through observation and guided practice. Articulation and reflection help the learners to focus their observations of expert problem solving and to gain conscious access to and control of their own problem-solving strategies. Exploration aims to encourage learner autonomy both in solving problems and in formulating problems to be solved. Learning theorists supporting cognitive apprenticeship model believe that instruction should focus on the zone of proximal development (Vygotsky, 1978), which refers to the range of knowledge and skills that learners are not ready to learn on their own but can learn with help from their teachers (Thaarp & Gallimore, 1988 cited in Brophy, 1998). The role of the teachers is to hold learners in their zone of proximal development by providing just enough help and guidance, but not too much (Perkins, 1991). Vygotsky defined the true advance in the child's reasoning as the difference between the child's independent performance and his or her performance in co-operation with an adult.

The cognitive apprenticeship model requires teachers to be role models for the various skills which the learners are required to develop. Teachers must be real readers, writers, mathematicians, scientists, and social scientists, rather than people who talk about reading, writing, mathematics, science and social science (Pressley & McCormick, 1994). This view is reiterated by Prawat (1992) who suggested that teachers should "create a microcosm of the disciplinary culture" (p.378) where teachers played the role of the practitioner modelling the process a mathematician might go through solving a problem, or that of a historian in accounting for why a particular event occurred. In the case of inquiry learning, teachers should serve as role models "in deliberating issues, in examining values, in admitting error, and in confronting areas of their own ignorance" (Welch et al., 1981, p.35).

Though little research has been conducted on the impact of cognitive apprenticeship in relation to science education, one can quite easily see the appropriateness of this model in the learning of scientific concepts and cognitive skills emphasised in the science curricula. Scientists have developed powerful concepts that are useful for describing and explaining many real world phenomena. Instead of providing these concepts or ideas to students in a decontextualised form, Prawat (1992) suggested that teachers could use a kind of cognitive apprenticeship to embed these ideas in authentic activities and getting students to use them to understand specific, real world objects and events. In fact, Hodson (1996) described a similar three-phase approach for school science which includes modelling where the teacher exhibits the desired behaviour, guided practice where students perform with help from the teacher, and application where students perform independently of the teacher. According to Hodson, "by engaging in holistic scientific investigations, alongside a trusted and skilled critic, students increase both their understanding of what constitutes doing science and their capacity to do it successfully" (p.131).

2.3.9 Science, technology and society

Science, technology and society (STS) is described as a reform effort to broaden science as a discipline in schools and colleges; to relate science to other facets of the curriculum; and to relate science specifically to technology and to the society that supports and produces new conceptualisations of both (Yager, 1996). Yager defined STS as the teaching and learning of science and technology in the context of human experience. Instead of a STS curriculum, STS is a context for a curriculum, thus is often referred to as STS movement, STS strategy, STS approach or STS instruction. It is aimed at setting science within an everyday social context, advocating that science should be linked both to applications in associated technology and implications in relation to the people in the society. The bottom line in STS is the involvement of learners in experiences and issues which are directly related to their lives, empowering them with skills and knowledge to enable them to become active, responsible citizens by responding to issues which impact their lives (Yager, 1993; Yager, 1996). The advocates of STS education propose that such education will better prepare students to live in an increasingly technological world by showing them the interconnections between science, technology and society in a more meaningful way (Shamos, 1993). STS has been called the current megatrend in science education (Roy, 1984 cited in Yager, 1996) and is widely recognised as a major reform effort to attain a scientific literacy for all (Yager, 1996).

STS involves using technology as a connector between science and society. STS has been regarded as an appropriate learning context for all learners (Tobin et al., 1994; National Science Teachers Association, 1990). This is because the applications of science such as advances and issues concerning food, clothing, shelter, transportation, communication and careers are seen as closer to the lives of students (Yager, 1996). A STS program will have built-in opportunities for the students to extend beyond the classroom to their local communities, or society in general. Common sources for STS approach include the home, student experiences, newspapers, journals, magazines, radio and television programs, the library, textbooks, and local, national, or international issues (Ajeyalemi, 1993).

The STS approach starts with students' questions and interests, rather than with predetermined sequence of the traditional lessons (Lutz, 1996). Once, the students have identified an area of interest to be investigated, they determine what resources to use, and proceed to gather information that will help them address the question or issue they have selected. Strategies commonly employed in the traditional science classroom teaching such as lecturing, questioning, explaining and demonstrating may also be useful for certain situations. Ajeyalemi (1993) described strategies that are much more typical of an STS class as those which are learner-centred such as field experiences, practical laboratory activities, case studies, simulations, role plays, debates, library searches, brainstorming, panel discussions, projects, class discussions, presentations, displays and invited guests.

The STS teaching strategy is consistent with constructivist learning theory which views learning as conceptual change (Ebenezer & Zoller, 1993; Lutz, 1996). Both promote students' understanding with students taking responsible action accordingly, and that teachers are expected to change their traditional role from that of provider of knowledge to that of fellow learner, reciprocator and negotiator. Lutz suggested that a constructivist approach can be achieved via an STS teaching strategy, resulting in students "who are independent learners, prepared to apply their knowledge to real life situations, and who are capable of making informed decisions about their lives in a world of modern science and technology" (p.48).

Studies have shown that learning science in an STS context enhances learners' creativity (Penick, 1996), their attitude toward science (McComas, 1996), their mastery of science concepts (Myers, 1996) and process skills (Wilson & Livingston, 1996), and in responsible personal decision making (Varella, 1996). Baker (1994) argued that setting science within STS contexts encourages students' active participation in asking questions, making links with prior knowledge which will consequently result in students' deeper understanding. He further suggested that the emphasis on the social and ethical could motivate reluctant learners of science, especially the girls. As STS instruction provides students with the interactive and context-driven instruction which all students can use to challenge themselves and grow regardless of ability, Olson and Iskandar (1996) saw the potential of STS instruction as the means for low ability students to meet with success.

STS may not be the only effective science teaching strategy. Looking at the success stories of the studies on STS teaching, it is worthwhile to nurture STS, along with other effective teaching varieties that have the potential to grow and flourish. At the moment, STS is a world wide reform effort in science education, not only in the Western countries, but also in developing countries in the Pacific (Yager, 1996)

2.4 Overview of Malaysian Primary Science Curriculum

The Malaysian Ministry of Education began science curriculum reforms in the primary school with the establishment of Special Project in 1968 which was aimed at improving the poor performance of pupils in primary school mathematics and science (Lee, 1992). In 1982, KBSR was introduced with much emphasis given to the learning of the 3Rs and the inculcation of moral values. Science was no longer taught as a separate subject in primary schools but as an integral part of a subject called 'Man and His Environment' which also included History, Geography, Civics and Health Science. In response to the perceived need of the country to produce more manpower in science-based jobs to meet the country's vision of becoming a fully industrialised nation by the year 2020, the policy makers in the Malaysian Ministry of Education decided that there was insufficient emphasis of science in 'Man and His Environment'. A new science curriculum was introduced to all primary schools beginning December 1994.

The primary aim of the science curriculum is to produce individuals who possess knowledge and skills which are necessary for a caring, dynamic and progressive community based on science and technology so that they can appreciate nature and act more responsibly towards their environment (Ministry of Education, Malaysia, 1993a). To achieve this, the curriculum emphasises pupils' understanding of basic science concepts and principles, acquisition of scientific skills and thinking skills, and the inculcation of scientific attitudes and moral values. The inclusion of moral values in accordance with Islam, highlighting the limitations as well as the strengths of science, is a unique feature in the Malaysian science curriculum which is not commonly found in the Western science curricula.

Another notable aspect of the syllabus was the teaching and learning of science in contexts that have meaning and relevance for pupils. A Science-Technology-Society perspective has also been emphasised in the curriculum as evident from the inclusion of a field of study on its own called 'Investigating the world of technology'. However, the curriculum does not seem to take into account the perspectives of particular groups of pupils in science learning. For example, there is no reference to issues such as girls and science, the different ethnic groups and science, and pupils with special abilities and special needs in science. These issues are included in many Western science curricula.

The primary science curriculum provides pupils with opportunities to develop their understanding of science concepts and principles through five fields of study. Acquisition of various skills and inculcation of attitudes and values are integrated across these fields of study. The five fields of study are:

1. Investigating the living world;
2. Investigating the physical world;
3. Investigating the material world;
4. Investigating Planet Earth and beyond;
5. Investigating the world of technology.

Each field of study is divided into Primary 4, 5 and 6. Achievement objectives and suggested learning experiences are formulated for all fields of study. Achievement objectives consist of general objectives and specific objectives. General objectives describe pupils' learning outcomes from three aspects, that is, cognitive, affective and psychomotor while the specific objectives specify pupils' behavioural learning outcomes. Suggested learning experiences are provided to guide teachers to plan activities in order to achieve the relevant objectives. However, teachers are encouraged to modify or add on any other appropriate learning experiences.

The science curriculum advocates experiential learning and emphasises an inquiry approach, which is described as finding information, questioning and investigating the phenomena in the surroundings. Though the curriculum document states discovery as the main characteristic of the inquiry process, it cautions the use of discovery learning for primary school pupils. Guided discovery is suggested as the effective approach for these pupils as they need teachers' guidance to discover a concept or principle through discussion, questioning or problem solving. It is also suggested that the inquiry approach may not be suitable for all topics and that certain concepts and principles are best taught by teacher direct instruction. Teachers are encouraged to use different teaching-learning strategies to enable pupils to acquire knowledge and scientific skills, and to practise moral values. In this way, pupils will become more critical, analytical and responsible. Experiments, discussions, simulations and projects are among the recommended teaching-learning strategies. A constructivist view of learning is also being promoted in one of the modules on teaching-learning strategies which gave importance to pupils' prior knowledge and conceptual change in learning (Ministry of Education, 1996d).

Evaluation is described as a continuous process to assess the level at which pupils have achieved the stated objectives. Teachers are required to use the feedback obtained from the evaluation to plan follow-up activities aimed at overcoming pupils' weaknesses and reinforcing their learning process. Aspects which are to be assessed include knowledge, skills, attitudes and values. Techniques recommended to test these three aspects include multiple choice questions, complete the sentences, short-answer questions, essay questions, observations and practical tests.

2.5 Summary

In the past three decades, significant advances in the field of epistemology and psychology have in some ways influenced the development of science education in schools. Learning psychology has largely moved away from its dominance in behaviourism towards a science of cognitive function and of constructivism. Epistemology, the field of philosophy dealing with the nature of knowledge and knowledge production, has moved away from empiricist and positivist views towards constructivist views. This has caused a shift from the content-based curriculum to those which are process-based in the 1960s and 1970s. Contemporary science education places emphasis on both the content and the process of scientific enquiry. The aim is to enable the students to acquire a meaningful understanding of basic scientific concepts. Learning is seen from the constructivist perspective, the conceptual change of students' existing ideas towards those of scientists' ideas. For elementary school pupils, concrete and realistic experiences coupled with appropriate 'minds-on' interaction between pupils and between teacher-pupils and high-order questions is seen as ensuring optimal conditions to facilitate pupils conceptual understandings. Other strategies such as simulation, role play, teacher explanation, discussion and resource-based strategies could also be used. The wide range of activities is seen as not only exposing pupils to the various modes of learning but also as ensuring that pupils have the opportunity to use the various scientific process skills which are necessary in scientific enquiry.

As a whole, the Malaysian Primary Science Curriculum has been developed from the perspective of current practices and educational theory, integrating relevant developments from Piagetian stage developmental theory, modern cognitive psychology and constructivist epistemology. Many of the contemporary international trends in science education such as emphasis on both content and process, constructivist view of learning, inquiry learning, learning in context, and the relationships between science, technology and society have been addressed in the curriculum.

CHAPTER THREE
CURRICULUM IMPLEMENTATION

This chapter begins with a literature review on the current status of science teaching with special focus on Malaysia. This is followed by a review of four key factors which have been identified as crucial in the successful implementation of an inquiry-based science curriculum. These factors are (i) the teacher, (ii) the cultural context of learning, (iii) the curriculum materials, and (iv) the assessment system. Teachers' professional development has been included as it plays a major role in increasing teachers' effectiveness in implementing a new curriculum. The chapter concludes with a review of the initiation processes involved in the implementation of Malaysian Primary Science Curriculum.

3.1 Current Status of Science Teaching

Despite series of curriculum reforms in the past three decades as described in Chapter Two, science teaching in many countries including that of developed nations, remains disappointing with falling standards in students' knowledge and understanding of science. In the United States, studies show that traditional approaches emphasising rote learning and content coverage at the expense of learning with understanding, continue to persist in elementary science classrooms in schools all over the country (Raizen & Michelson, 1994; Tobin, Briscoe, & Holman, 1990); high school science classrooms are dominated by exposition as the primary mode of instruction, with little laboratory and field work (Lynch, 1997). Similar pictures of science teaching are also reported in Australia (Wallace & Louden, 1992) and in the United Kingdom (Department for Education and Science, 1983 cited in Fortune, Peters, & Rawlinson-Winder, 1993).

The unsatisfactory state of science teaching-learning has also been reported in the Malaysian classrooms (Ministry of Education, Malaysia, 1993b, 1995d, 1996e, 1997a; Syed Zin & Lewin, 1993). For example, the Sabah School Inspectorate 1996 annual report (Ministry of Education, Malaysia, 1996e) reported the following status of the teaching-learning strategies deployed by primary science teachers.

> Generally, teachers practised 'teacher-centred' teaching strategies. Science process skills and manipulative skills were given little emphasis. Pupils' participation was limited. Practical work was rare. There were some teachers who were incompetent in the use of science equipment such as the Bunsen burners, microscopes and electric circuits.

> Teachers' questioning techniques were unsatisfactory. Questions asked were unable to stimulate pupils' thinking process. Questions requiring 'yes' and 'no' answers and chorus answering were found to be rampant. Pupils very rarely asked questions.
>
> The majority of the primary science teachers seldom provided positive reinforcement and encouragement to the pupils.
>
> Even though teachers generally had a fair knowledge to teach science, their science content knowledge lacked breadth and depth to enable them to integrate various aspects effectively to make the lessons more interesting. Very often, teachers depended solely on the textbooks for information. There were instances where teachers used the wrong terms and presented wrong concepts.
>
> Even though many teachers were trying to integrate moral values into their science lessons, the development of learning skills and thinking skills have yet to be implemented effectively.
>
> Evaluation on pupils' achievement was based on their ability to memorise facts and information and seldom on their science process skills and manipulative skills as they themselves were still very vague on these aspects. (pp.106-107)

The report of the Science Committee on Improving the Quality of Science Education in Schools (Ministry of Education, Malaysia, 1993c) revealed that many teachers of 'Man and His Environment' were unable to understand fully the curriculum or to translate it effectively into practice in their classroom. Based on the result of the achievement test on the science component of 'Man and His Environment' carried out in 1992, the same report revealed that the majority (86 per cent) of primary six pupils were unable to answer questions which tested analytical and inferential skills.

The findings of a nationwide survey by the EPRD (Education Planning and Research Division) on the implementation of the new primary science curriculum study revealed that a large proportion of the teachers continued to use the didactic approach to teach science instead of the inquiry approach as advocated in the new curriculum (Ministry of Education, Malaysia, 1997a). The survey report pointed out that teachers' poor science background was found to have affected their capabilities to vary their science teaching strategies. This consequently led to the teachers adhering strictly to direct instruction based on the content found in textbooks or other reference books, resulting in much rote learning and little inquiry learning among pupils.

This pattern of findings about science teaching in Malaysia is not confined to the primary level. Nationwide studies done by Syed Zin and Lewin (1993) on secondary science education also reported findings of teaching strategies which were not congruent with the inquiry learning advocated in the curriculum. It was reported that many secondary science teachers conceived of science curricula as primarily defined by scientific facts and few teachers stressed the development of intellectual skills among their students. Syed Zin and Lewin observed that much science teaching was heavily knowledge-based and teacher-centred with little input from students. They reported that science teaching was examination oriented and did not offer much opportunities for students to develop a full range of scientific thinking skills. Questions were confined to lower cognitive levels, mostly involving the recall of information rather than requiring reasoning and interpretation. Practical work tended to be like following recipes. While it provided some hands-on experience, it offered little opportunity for minds-on experience.

3.2 Key Factors Affecting Curriculum Implementation

Policy makers often behave as though the policy making process is virtually complete when a new law has been passed and the writing of regulations and curriculum documents are completed. Darling-Hammond (1990) and Fullan (1991) compared the large amount of time and effort concentrated on product development of the new educational policies to the little time and effort in planning for curriculum implementation. According to them, this could have been one of the contributing factors to the unsatisfactory state of science teaching in the classrooms. While no one can deny the importance of well-designed curriculum documents, the planning of the curriculum implementation needs to take into account several other factors to ensure a higher rate of success during the implementation process. This section reviews four factors which have been identified in the literature as crucial in the implementation of any new curriculum with particular reference to the implementation of an inquiry-based science curriculum. The factors are (i) the teacher, (ii) the cultural context of learning, (iii) the curriculum materials, and (iv) the assessment system.

3.2.1 Teacher

A shift from a traditional content-based science curriculum to an inquiry-based science curriculum requires fundamental changes in teachers' views on various aspects of science education. It challenges teachers to change their views of scientific knowledge and of teaching and learning science, which eventually should lead them to change their classroom activities and their role as a teacher. At present, there seems to be a wide gap between teachers' existing knowledge and understanding of these various aspects of science education, and the knowledge and understanding necessary to effectively implement an inquiry-based science curriculum.

Different categories have been used to describe the knowledge that teachers need to understand to bring about learning and understanding in their students. These include Hollingworth's (1989) subject matter knowledge, general pedagogy, and the ecology of learning in classrooms; Smith and Neale's (1989) substantive content knowledge and pedagogical content knowledge; and Shulman's (1987) seven categories of knowledge: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, curricular knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. It is argued here that, for effective implementation of an inquiry-based science curriculum, teachers should have adequate understanding of (i) science content knowledge, (ii) the nature of science, and (iii) pedagogical content knowledge.

i. Science content knowledge

Teachers' lack of science subject knowledge has been widely quoted as the main cause for poor science teaching in elementary schools. Carré and Carter (1990) perceived subject matter knowledge as being fundamental to the structure of teacher knowledge which, in turn, is instrumental in helping teachers make decisions about management planning and action. According to Carré and Carter, a teacher cannot teach what he or she does not know, with the teacher's creativities and abilities to take initiatives depending a great deal on his or her knowledge base. Carré and Carter reported of teachers who have been found to often rely on common-sense knowledge and to have misconceptions of various science concepts which they are required to teach. It is argued that the interactions between children's science and teacher's science have profound implications in terms of whether children can achieve coherent understanding of science concepts. Ideally, teacher' science should be that of scientist's science. However, this is often not so. Gilbert et al. (1982) described teacher's science as ranging from children's science to scientists' science. It would be difficult to visualise how a teacher, with misconceptions of a concept that he or she is teaching, could interact with his or her pupils to ensure their coherent understanding of the concept.

Harlen and Holroyd (1997) described teachers who used various coping strategies to offset their lack of science background knowledge. These strategies included teaching little of the subject, focusing more on a higher-confidence aspect, placing heavy reliance on textbooks and work cards, emphasising expository teaching, and underplaying questioning and discussion. These teachers were reported to have avoided all but the simplest practical work and any apparatus that could go wrong.

Harlen and Holroyd were concerned that if these strategies are regularly applied, they would have severely limiting effect on children's learning.

Shulman (1987) argued that teacher comprehension of science concepts is even more critical for the inquiry-oriented classroom than for its more didactic alternative. A teacher with limited science knowledge might not be aware of students' misconceptions, or might not be able to offer students viable alternative explanations (Appleton, 1995). Silvester's (1989) study showed that teachers are more comfortable attempting to change a teaching style with concepts that they feel confident about, rather than those which are unfamiliar to them. It is therefore important that science teachers should have adequate knowledge and understanding of the concepts that they are required to teach. Teachers' proper understanding of these concepts will not only ensure that their students are more likely to achieve coherent understanding of various science concepts, it will also increase their confidence in adopting an inquiry-based approach to science teaching.

ii. Nature of science

Various studies have been undertaken to investigate teachers' views of the nature of science (Abell & Smith, 1994; Behnke, 1961; Carey & Stauss, 1968; Collins, 1989; Gallagher, 1991; Koulaidis & Ogborn, 1989; Schmidt, 1967). In Gallagher's study, the majority of teachers held traditional positivistic views of science that emphasised the scientific method and the objective nature of science. They presented a traditional positivistic view of science even when the textbooks portrayed a more constructivist view of science. The same study found that even teachers who had a strong background in the history and philosophy of science, portrayed science as an objective body of knowledge. The study done by Abell and Smith revealed that pre-service elementary teachers had realist and positivist views of the scientific enterprise with little emphasis on the social or creative dimensions of the discipline. Koulaidus and Ogborn's study of young science teachers in the United Kingdom showed some evidence of a general shift of teachers' views from the empirical-inductive position towards a more contextualist-relativist view. In a review of studies to investigate teachers' views of the nature of science, Lederman (1992) concluded that teachers did not possess adequate conceptions of the nature of science irrespective of the instrument used. Many of them held positivist and realist assumptions that scientific knowledge is the transcendental and permanent truths discovered about the universe. According to Abell and Smith, these teachers seemed to have formed naive realist and positivist ideas about science constructed over years of formal science instructions.

Lederman (1992) also reviewed the findings of studies carried out to improve teachers' conceptions of science. He concluded that techniques that included either historical aspects of scientific knowledge or direct attention to the nature of science, have met with some success in improving teachers' conceptions of science.

Research has suggested teachers' views of science may have a considerable influence not only on what science is taught but also on how it is taught (Lakin & Wellington, 1994; Lederman, 1992). Smith and Anderson's (1984) study reported that a science teacher who believed that scientific theories were inferred from observation was surprised when her students failed to discover photosynthesis by observing the growth of plants. Lantz and Kass (1987) found that three high school chemistry teachers with different understanding of the nature of chemistry taught very different lessons about the nature of science. In an intensive study of three science teachers with varying backgrounds and experiences, Brickhouse's (1990) study showed that their views about science shaped an implicit curriculum concerning the nature of scientific knowledge.

Abell and Smith (1994) argued that teachers' views about the nature of science could either enrich or limit the kinds of science that children did in classrooms. In Hashweh's (1996) study, teachers who held constructivist beliefs were found to have a richer repertoire of teaching strategies. These teachers used potentially more effective teaching strategies for inducing student conceptual change. However, teachers who possessed the positivist nature of science were found to give more attention to concepts and principles of science rather than to the process by which scientific knowledge was formulated. Aguirre, Haggerty, and Linder (1990) suggested that teachers' positivistic-empiricist view of science may be a significant disposition leading them to adopt a transmissive approach to teaching.

The above literature indicates that the majority of teachers possess a positivist-realist view of science which might have contributed to their expository teaching style and their heavy reliance on textbooks. Teachers who hold a positivist-realist view of science undervalue the personal and social dimensions of knowledge construction and thus, are reluctant to adopt a constructivist approach in science teaching and learning. Therefore, there is a need to portray richer images of science to these teachers if they are to successfully implement an inquiry-based science curriculum.

iii. Pedagogical content knowledge

Subject matter knowledge is not the only important factor informing teachers' judgement and professional action (Carré & Carter, 1990; Morrison, 1989; National Research Council, 1996). Equally important is the knowledge about children, teaching strategies, communication skills, curriculum knowledge, teaching-learning theories, and classroom management. Carré and Carter considered it crucial for teachers to be able to translate science concepts into appropriate and useful instructional representation, thus enabling children to assimilate abstract ideas. Shulman (1986) used the term pedagogical content knowledge to describe the form of knowledge which enables the teachers to transform subject content knowledge into a form readily accessible to their students. Shulman described pedagogical content knowledge as:

> a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding. ... It goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching. It is that particular form of content knowledge that embodies the aspects of content most germane to its teachability. (p.8)

Pedagogical content knowledge shifts the focus of learning to teach from mere acquisition of a set of pedagogical skills with which to transmit a fixed body of knowledge to the more challenging task of inquiry into subject content knowledge and its teachability (Geddis, 1993).

Various studies revealed that both beginning and experienced teachers hold a variety of different conceptions of teaching science. Of the 74 secondary student teachers in Aguirre et al.'s (1990) study, half of them regarded teaching as a matter of knowledge transfer from teacher to the 'empty' minds of children and learning as just an intake of knowledge. Only one third of them recognised the importance of learners' prior knowledge and believed that new information should be related to existing understanding. Weinstein's (1989) study to investigate pre-service and in-service primary and secondary teachers' conceptions of good teaching found that both pre-service and in-service teachers tended to emphasise interpersonal and affective variables such as caring and concern for children, ability to relate to students, patience, and enthusiasm. Both groups of teachers rarely referred to the academic or cognitive dimensions of teaching such as promoting critical thinking or problem-solving, fostering knowledge or skills acquisition, or teaching children study skills. According to Weinstein, conceptions of teaching that omit cognitive concerns are incomplete and tend to diminish the importance of pedagogical and subject matter knowledge.

As school science curriculum emphasises learning of scientific skills and thinking skills, teachers must possess the necessary knowledge and skills in order to facilitate pupils using these skills in the learning of science concepts. Teachers also require the necessary skills in using the inquiry approach to teach science. In Aubusson's (1994) study, all the teachers regarded thinking as something which was learnt incidentally in that it was not directly discussed and analysed. These teachers viewed thinking as an operation learnt and developed by students when they engaged in it rather than as a subject students discussed or about which students should be told. Thinking is learnt and taught tacitly as part of a gradual process promoted by general approaches to teaching. Science contributes to this by providing a source of open-ended investigations and problems which stimulate thinking and the scientific method as a model of problem solving to invigorate students' thinking process. The only way to enable pupils to develop a wide range of scientific skills and scientific attitudes is to provide them with plenty of opportunities to practise these skills and to experience these attitudes. This can be achieved by careful planning by the teachers in introducing a wide range of relevant activities.

The above literature indicates that many teachers possess a narrow repertoire of pedagogical content knowledge. Hewson, Kerby, and Cook (1995) were concerned that this might result in limited professional knowledge development leading to ineffective teaching practices. It is therefore important that teachers should be exposed to a wide repertoire of pedagogical content knowledge based on research done on effective teaching and learning.

3.2.2 Cultural context of learning

Prophet (1990) reported the situation in Botswana where, within a family, a relatively rigid rote-learning approach to child-rearing is directed towards producing a mannerly, conforming and industrious person. Similar situations exist in Asian countries including Malaysia. In the Malaysian culture, teachers called 'guru' are regarded as elders like the priests and the 'iman' who hold valuable knowledge and set themselves as authority figures whose word is not to be questioned (Ling & St. George, 1998). In such a situation, students are to remain passive and listen attentively to the teachers. Thus, the values instilled in a typical Malaysian home are often in fundamental disagreement with the spirit of inquiry and critical questioning required by the inquiry-based curriculum.

Alverson (1977, cited in Prophet, 1990) suggested that this is being reflected in the passive and accepting atmosphere observed in the classroom where learning is unreflective and by rote. Asian students generally are seen as responding to the instructions of the teacher rather than initiating behaviours to promote their own learning (Purdie & Hattie, 1996). Students are actively discouraged from asking questions or speaking up in class as a student may have to remain standing until a right answer is given (Macann, 1997). Even when a student knows that the teacher has made some mistakes in his or her presentation, usually the student will not confront the teacher. Pointing it out in front of the class would have the student labelled as showing off and being disrespectful to the teacher. To question the teacher is often regarded as questioning the authority and competency of the teacher, which is often considered as a sign of disrespect to the teacher. A student challenging the teacher's ideas would be seen as showing an even greater degree of disrespect (Ling & St. George, 1998).

Elements of conceptual change teaching-learning model which encourages students to adopt a critical and questioning stance, would be seen as opposing the norms of conformity and respect inherent in the existing culture of many Asian and African countries. There is a need to develop culturally appropriate ways of encouraging students' participation in questioning, seeking clarification and challenging ideas, without losing the element of respect towards the teachers.

3.2.3 Curriculum materials

Some authors seem sceptical about the potential of curriculum materials in the curriculum implementation process and have more confidence in the training of teachers with appropriate instructional skills in ensuring successful curriculum implementation (Van Den Akker, 1988). Collins (1997) considered the importance of the quality of teachers over that of curriculum materials to ensure a new way of teaching and learning science that supports student understanding, According to Collins, excellent teachers could teach for understanding even with poor materials, and poor teachers could fail to teach science understanding with excellent materials. The search for an effective combination of the two strategies rather than that of mutually exclusive strategies might be more appropriate in ensuring successful curriculum implementation.

Because of the cost-effective potential of curriculum materials in contrast to in-service courses and workshops (Westbury, 1983), well-designed curriculum materials could improve the implementation process and outcomes (Barrow, 1984; Van Den Akker, 1988).

As it is not likely for all teachers involved in a curriculum reform to participate in in-service courses and workshops, well-designed curriculum materials could support the teachers by providing a clear orientation to the teaching task, pointing to critical features of lessons, anticipating potential problems in use, and offering practical advice to prevent or solve such problems (Clark & Peterson, 1986; Shavelson & Stern, 1981). Van Den Akker stressed the importance of curriculum materials as:

> Curricular materials stimulate the teachers to a more elaborate and accurate 'internal dialogue' about the what, when, how and why of their own teaching role, and provide them with clear advice about the implications of these matters for classroom practice. (p. 55)

According to Hollon, Roth, and Anderson (1991), appropriate curriculum materials could reduce the cognitive and technical complexity of the tasks involved in conceptual change learning. Such materials could help teachers to routinise these tasks, freeing cognitive capacity and real time to improve on those tasks that did not lend themselves to simplification.

Van Den Akker (1988) investigated Dutch primary teachers' view of their preferred science curriculum materials. The study found that even though all teachers expressed a need for exemplary lesson materials, they differed in their preference for the design of the materials. Experienced teachers were reported to prefer open materials while less experienced teachers preferred a more structured and explicit design. The study also revealed that for teachers' initial use, a structured approach was more effective. In other words, curriculum materials should contain a large amount of procedural specification on essential elements of the curriculum. Van Den Akker described this as particularly essential at the initial implementation phase where personal and survival concerns are of utmost importance to teachers. According to him, such materials could "support the teachers by anticipating as far as possible potential problems in use and offering practical advice to prevent or solve such problems" (p. 50). This will enable the teachers to experience the spirit of the program in their role-taking behaviour.

Smith and Anderson (1984) described the process of promoting conceptual change in science as considerably challenging for the teachers. They stressed the importance of the curriculum materials being able to provide teachers with specific help to meet the challenge. Smith and Anderson suggested,

> Teachers need more than a set of suggested steps to follow: they need to understand the purposes of the recommended activities. Specific information about students' likely preconceptions, activities that will generate evidence that confronts students' misconceptions, and explanations of how that evidence may be used in bringing about desired conceptual changes provide a knowledge base that may allow many more teachers to successfully meet this challenge. (p.696)

Puk and Haines (1988) recommended that curriculum materials should contain fully-developed units that teachers can either follow closely or can adapt to their own needs. They suggested that this can be done by providing practical examples of the teaching-learning process being featured in the curriculum. It is also important that these examples should make use of resources which are readily available to the teachers. Highly relevant and desirable activities requiring resources which are inaccessible to the teachers are deemed to be of no help to the teachers.

Roberts (1988) reported that it was not uncommon for teachers who received a new science curriculum policy document to flip through it and put it on the bookshelf to gather dust. The incomprehensibility of the document could have been one of the causes for such action. Utting (1992), in commenting on the New Zealand Science Curriculum Statement, argued for a "Science Curriculum Statement for All" (p.7). Utting argued that science curriculum materials should be comprehensible to all the intended users including the 'average' and the 'below-average' primary teacher-users. According to him, teachers tended to use materials which were simple, clear, and user-friendly. Jargon and technical terms could easily put off many teachers. Utting questionned the appropriateness of the use of terms such as "physical world", "material world", "achievement aims", "achievement objectives", "achievement levels", "making sense of", "strands", and "sample learning contexts" in the New Zealand Science Curriculum Statement. According to Utting, these terms might not be comprehensible to many of the teachers and they should be substituted with simpler terms so that teachers can fully understand the curriculum policy before implementing it.

Raizen and Michelsohn (1994) realised that elementary teachers rarely have the time, resources, or expertise to create lessons for each topic they have to teach. They raised the need of providing these teachers with the many curriculum materials for elementary school science that already exist. More teachers would be encouraged to experiment with student-centred learning if comprehensive resources were available (Torrie, 1991). While acknowledging New Zealand's limited ability to finance well researched, trialled and tested materials, Torrie suggested looking somewhere else for a starting point. As the aims and objectives of the Salters Science Course closely mirrored those of the New Zealand science course, Torrie suggested the possibility of adapting the Salters Science Course materials developed by the University of York Science Education Groups in the United Kingdom to local contexts by producing a local version of the course. This would not be as difficult, expensive or time-consuming as developing a new package. Votaw (1992) introduced three sources of science materials available in the United States to pre-service and in-service teachers in New Zealand. These materials were (i) GEMS (Great Explorations in Math and Science) from the Lawrence Hall of Science at the University of California at Berkeley, (ii) TOPS Learning System from Ron and Judy Marson of Canby, Oregon, and (iii) National Science Resource Centre (NRSC) from a coalition of the Smithsonian Institution and the National Academy of Science, Washington, DC.

By adapting other countries' tested curricular materials, those countries which have limited ability to finance well-researched and trialled curriculum materials, such as Malaysia, could benefit from the years of research, development and trialling that has already been done by the publishers of the materials. Malaysian science curriculum developers from these countries could explore the possibility of looking for well-researched and tested science curriculum materials from the USA, UK, Australia, New Zealand and perhaps neighbouring countries like Singapore, and adapting them to the local contexts. Raizen and Michelsohn (1994), stressed the importance of teachers being provided with opportunities to review an assortment of science curriculum materials, including both superior and inferior examples so that they can distinguish and make choices among materials in their attempt to use these materials in their classrooms.

3.2.4 Assessment system

It is common knowledge that assessment has a strong influence on teachers' practice. Harlen (1992) suggested that the swiftest way to change teaching would be to change the assessment system. This is particularly so in countries where school examinations assume high profile, resulting in the assessment system leading the curriculum rather than following it. As Millar, Osborne, and Nott (1998) put it, "Change in the curriculum without change in assessment is simply like rearranging the deck chairs on the*Titanic* - it looks different but has no effect on the direction in which the ship is going" (p.23). Cizek (1993) described the influence of tests and examinations as weighty because of the substantial rewards and sanctions often related to students' performance. Psychometricians and curriculum specialists often have divergent views of teaching and learning. When assessment is of utmost importance, the measurement specialists rather than the curriculum specialists exert substantial control over classroom instruction through the mechanism of the test.

Cizek claimed that a greater congruence of learning theories held by testing, curriculum, and instructional personnel would be more desirable. The content and form of an assessment task must be congruent with what is supposed to be measured. In the case of the Malaysian primary science curriculum, which promotes understanding of scientific knowledge, development of scientific skills, thinking skills and scientific attitudes, assessment should take into account all of these aspects, not mere description or definition of facts, concepts or principles.

The social expectation in countries like Malaysia reinforces the teachers' conception that the traditional didactic approach to learning scientific facts is the most effective teaching-learning strategy. This adds further restraint to the teachers trying to implement the progressive learning espoused in the new curriculum. Detailed analysis of the passing rate, the number of straight A students by state, names of schools with the highest passing rate, and schools with the highest percentage of straight A students are published. At one stage, the Education Minister tried to stop the comparisons of results between schools and states as it was realised that the results were affected by local logistical, environmental and socio-economic factors (Daily Express, 14 December 1997). Nevertheless ranking schools by passing rates continues today.

At present, there is recognition among Malaysian educationists that the education system is too examination-oriented. Moreover, these examinations often demand low-level cognitive learning to recall facts. Attempts are being made to gear the whole education system in the country towards a system which places more emphasis on pupils' ability in thinking and reasoning instead of just memorising facts (The Star, January 16, 1999). There is little reward for teachers to change to a style of teaching which emphasises high-level cognitive learning and laboratory activities if the assessment system continues to promote recall of facts (Tobin, Espinet, Byrd, & Adams, 1988). Science education reform effort may be accelerated or enhanced when state or national assessments closely match reform goals (Weiss, 1995 cited in Lynch, 1997). As assessment is a powerful tool in influencing the type of instruction happening in science classrooms, it dictates the way in which teachers implement the curriculum.

3.3 Teacher Development and Curriculum Implementation

Mounting evidence indicates that reform efforts require a great deal of time and effective professional development to affect teachers' teaching practices and eventually student outcomes (Lynch, 1997). According to Fullan (1991), many attempts at policy and program change have ignored the fact that what people did and did not do was the crucial variable which affected whether or not an initiated change happened in practice. Darling-Hammond (1990) considered it unrealistic to expect teachers to change their beliefs, knowledge and actions based on a change process that consisted primarily of the issuing of curriculum statements and the adoption of new texts. Since many teachers were unsure of what the policy really consisted of, and what it meant for their teaching, they could not fully engage its implications intellectually. According to Darling-Hammond, investments in teachers' development are paltry compared to the staff development that occurs in other professions. As described by Osborne and Simon (1996), "Just as the industry which fails to invest in new plant and technology is doomed, so is the education system of a country which fails to provide sustained training and education of its teachers" (p.141).

The inquiry mode of teaching science as advocated in the present day science curricula implies change for many groups of professionals including teachers, administrators and other individuals charged with implementing these curricula. Teachers are the most immediately affected as they ultimately determine the extent to which any innovation occurs in the classroom. The change from a teacher-centred, content-oriented, textbook-dependent way of teaching science to a hands-on minds-on inquiry approach is particularly difficult for many teachers. They need proper training and support to help them to overcome the problems they faced in trying out a new approach to teach science.

Fullan and Pomfret (1977) observed that effective curriculum implementation consists of alterations in curriculum materials, instructional practices and behaviour, and beliefs and understanding on the part of teachers involved in given innovations. Thus, successful change involves learning how to do something new and the process of implementation is essentially a learning process. In so far as the introduction of a new curriculum, teacher development and implementation go hand in hand. In this context, teacher development can simply be defined as those processes that enable teachers to learn the necessary knowledge, skills, or attitudes to implement the curriculum. This can be achieved through the more formal teacher education programs and the continuous school-based teacher development made available to the teachers during the course of curriculum implementation.

3.3.1 Teacher education programs

Sparks and Loucks-Horsley (1990) described two assumptions that undergird the training model of teacher professional development. The first assumption is that there are behaviours and techniques worthy of replication by teachers in the classroom. The second assumption is that teachers can change their behaviours and learn to replicate behaviours in their classroom that were not previously in their repertoire. Whether considering in-service or pre-service teacher education, there are general issues to be considered to enable the teachers to successfully implement a new curriculum. This section reviews the literature on models of teacher education, followed by a discussion on how these models can be applied in the development of appropriate pedagogy to be used in science teacher education programs.

Models of teacher education

Tom and Valli (1990) listed positivism, interpretivism, craft knowledge and critical theory as four traditions or orientations of teacher education. These orientations are parallel to the four paradigms of teacher education by Zeichner (1983) which include: (i) behavioristic teacher education, (ii) traditional-craft teacher education, (iii) personalistic teacher education, and (iv) inquiry-oriented teacher education. The main characteristics of these paradigms are summarised in Table 3.1.

i. Behavioristic teacher education

Tom and Valli (1990) used the term 'positivism orientation' to describe this model of teacher education. In this orientation, teachers are to master a body of professional content knowledge and teaching skills which are in the form of a set of laws (Zeichner, 1983). These laws which are derived from research embedded in the psychological tradition, behaviourism in particular, are supposed to predict human behaviour and guide teaching (McGee, 1995). Teaching is viewed as an applied science and the teacher as an executor of the laws and principles of effective teaching (Tom, 1980).

ii. Traditional-craft teacher education

Here, teacher education is viewed primarily as a process of apprenticeship, where "a master-apprentice relationship is seen as the proper vehicle for transmitting the cultural knowledge possessed by good teachers to the novice" (Zeichner, 1983, p.5). Teaching is regarded as a practical craft centred on classrooms and the meeting of children's needs (Snook, 1993). This is achieved by a teacher who understands children, familiar with all aspects of the curriculum, has sound teaching methods, and the ability to control a class. According to this model, knowledge about teaching is accumulated by trial and error and is to be found in the wisdom of experienced practitioners (Floden & Lanier, 1979 cited in Zeichner). Zeichner described much of this accumulated knowledge as tacit and therefore not amenable to the kind of specification that has been described in the behavioristic model.

iii. Personalistic teacher education

Advocates of this paradigm of personalistic teacher education contend that the content of a teacher education program should be largely based upon the self-perceived needs and concerns of prospective teachers and have constructed a developmental model of teacher concerns which has been used to conceptualise the design of teacher education programs (Fuller, 1974). This model promotes the psychological maturity of prospective teachers and emphasises the reorganisation of perceptions and beliefs over the mastery of specific behaviours, skills and content knowledge. Consequently the knowledge and skills that prospective teachers are to master, are rarely defined in advance to the same extent as that in the behavioristic teacher education. The specification of a particular set of behaviours for all teachers to master is viewed as antithetical to the development of mature and competent teachers. Competence in teaching is equated with psychological maturity, and prospective teachers are encouraged to find their own best ways to function as teachers.

iv. Inquiry-oriented teacher education

This orientation to teacher education prioritises the development of inquiry about teaching and about the contexts in which teaching is carried out. Zeichner (1983) cited the proposals for the development of "teacher innovators", "teachers as action researchers", "teacher scholars", "self-monitoring teachers", "teachers as participant observers", and "teachers as inquirers". According to Zeichner, all of these were attempts to develop prospective teachers' capacities for reflective action and thus the skills to analyse what they are doing in terms of its effect upon children, schools and society.

Unlike the personalistic model, meeting the needs of prospective teachers is not the central concern. The inquiry-oriented model focuses on the development of technical skills in teaching and the mastery of content knowledge within the framework of

Table 3.1: Four Paradigms of Teacher Education

	Behavioristic	Traditional-craft	Personalistic	Inquiry-oriented
View of teaching	Teaching as an applied science.	Teaching as a practical craft, a technical activity.	Teaching as a development process for teachers	Teaching as a learned profession, teaching as inquiry
Role of teacher	Teachers are passive recipients and play little part in determining the content and direction of the program. Teacher as executor of the laws and principles of effective teaching.	Teachers are relatively passive recipients. Teachers become more effective as they learn by practice.	Teachers are active participants in the construction of curricular content Teachers develop their own teaching style.	Teachers as active learners. Teachers as motivators, facilitators, action researchers, inquirers.
Sources of teacher knowledge base	Based on a positivistic epistemology and behavioristic psychology derived mainly from research.	From wisdom of expert practitioners.	Builds on teachers' existing knowledge and skills.	Teachers develop new understanding as they contribute to and formulate their own questions and collect their own data to answer them.
Program focus	Emphasises educational theories. Focuses on mastery of a body of professional content knowledge and the development of a set of predefined teaching skills. Teacher competence is determined by their performance at a prespecified level of mastery of this knowledge and skills. Teachers expected to put theoretical knowledge and skills into classroom practice.	Emphasises technical skills. Focuses on learning teaching skills from expert practitioners. Learning of these skills is a low level replicative task. Trial and error is the only way to improve such skills. Emphasises apprenticeship model. using modelling and guided practice. Advocates school-based approach.	Emphasises on teacher personal development of knowledge and skills. Curricular content and pedagogy based on personal needs and concerns of individual teachers. Does not specify a set of knowledge and skills to be learnt.	Correlating theory and practice. Focuses on intellectual professional growth. Development of technical skills in teaching and mastery of content knowledge and skills are addressed within the framework of critical inquiry. Values knowledge and skills in teaching as a means for bringing about desired ends and not as an end in itself.

critical inquiry. The assumption underlying this approach implies that technical skill in teaching is to be highly valued not as an end in itself, but as a means for bringing about desired ends. Sparks and Loucks-Horsley (1990) identified research as an important activity for teachers in the inquiry model of teacher education. Here, the individuals or groups of teachers identify a problem of interest and they explore ways of collecting data either by examining existing theoretical and research literature or by gathering original classroom or school data. Sparks and Loucks-Horsley concurred that as a result of learning more about research, “teachers make more informed decisions about when and how to apply the research findings of others; teachers experience more supportive and collegial relationships; and teaching improves as teachers learn more about it, being better able to look beyond the immediate, the individual, and the concrete” (p.244).

Current teacher education programs

Teacher education programs have been criticised both for their theoretical orientation and for their technical orientation. An area of concern in the literature on teacher education programs is the dichotomy between theory and practice (Goodlad, 1991). The issue of the theory-practice gap in teacher education programmes is one of the major criticisms of policy makers, researchers, authors, student teachers and practising teachers alike (Knight, Lingard, & Bartlett, 1993). In the preliminary analysis of a year long study of six student teachers, Rodriguez (1993) reported that these student teachers felt that their academic work was unrelated to teaching. The advocates of the behavioristic teacher education hold that teaching will only become truly professional when clear unequivocal professional skills and practices are identified and included in teacher education programs (Goodlad). However, many have questioned the context-free generalisations of this orientation. For example, Fenstermacher (1986) argued that the reality of human life is so complex and unpredictable that it cannot be reduced to objective law-like generalisations and this applies to teaching. There are claims that positivism has not provided the teaching effectiveness as had been predicted (Beyer, 1986).

As a result, one of the most recent changes in teacher education in some countries is increased field-based teacher education. In Britain, Secretary of State for Education announced in January, 1992 that the Post Graduate Certificate of Education courses for prospective secondary teachers were to be 80% schools based and the BA and BEd route was to be shortened (Snook, 1993). Despite the reluctance of teacher educators to affiliate themselves with this craft-orientation style of teacher education, this paradigm is still very much alive and well in the form of the heavy emphasis on typical student teaching experience (Zeichner, 1983). Field-based teacher education suggests a narrow definition of teacher training, limited to the technical operations which teachers are expected to perform (Marks, 1996).

Even though many teacher trainees give the highest marks to their experience in schools, Snook (1993) argued that this should not be taken as an argument against theoretical studies. While it is natural for a person preparing for a profession to view the time in the workplace as most relevant, his argument is that students learn a lot less in this way than they think. The value of field experience is dependent on prospective teachers being properly prepared to learn from it (Lanier & Little, 1986). There is plenty of evidence that teachers do not learn from experience to promote pupils' progress (Desforges, 1995). Experience in classrooms is not treated by teachers as critical material for the sustained pursuit of effectiveness and efficiency in promoting children's learning. Teachers appear to behave in order to maximise predictability in classrooms (Doyle, 1986). When their routine operation does not appear to get predictable pupils' behaviours, they put in place those actions which are intended to return classroom interaction to normal status (Brown & McIntyre, 1993). Teachers expressing child-centred philosophies of teaching were unaware that they tightly controlled lessons, including choosing contents and directions and initiating, sustaining and terminating almost all activities. Maskill and Selles (1995) argued that putting student teachers into schools for a longer period during training will not in itself improve the quality of the training experience unless the teachers are able to make it more productive. The underlying suggestion here is that there is no cause to be alarmed about the increased field-based teacher education, but to ensure the maximum benefits, a planned and properly co-ordinated partnership scheme must be built on existing good practice and rooted in sound educational theory (Everton & White, 1992 cited in Marks, 1996).

Generally, teacher education programs have been criticised by policy makers and the public for not producing the type of teachers that could improve the quality and standard of schooling (Apple & Jungck, 1992). As the demands on education expands from mere emphasis on content knowledge to that of higher level cognitive skills, the behaviourist and the traditional-craft paradigms of teacher education are unable to fulfil these demands. However, there is no doubt that these two paradigms of teacher education will continue to play their roles in equipping teachers with the knowledge and skills of classroom teaching. The constructivist theory of learning which recognises the student teachers' and teachers' perceptions of teaching and learning, is giving way to more reflective models of teacher education such as the personalistic and inquiry-oriented models of teacher education as described earlier.

Science teacher education programs

Recent science curricula have shifted the emphasis from mere acquisition of scientific knowledge to gaining meaningful understanding of science concepts through inquiry learning. These curricula also emphasise the development of scientific skills and thinking skills in students. A combination of the four models of teacher education described in the preceding section, can be used to develop the appropriate strategies in delivering teachers' knowledge in science teacher education programs. Yager and Penick (1990) suggested that the best kind of science preparation for teachers depends upon the kind of science program envisioned for the school. For a school science program that emphasises coherent understanding of scientific concepts, acquisition of scientific skills, and inculcation of scientific attitudes, the following strategies are considered appropriate in the teacher preparation programs. These include (i) 'hands-on' and inquiry approach, (ii) modelling and guided practice, (iii) conceptual change learning, and (iv) didactic instruction.

i. 'Hands-on ' and 'inquiry' experience

Findings of a number of studies to investigate elementary teachers' operational levels indicate that a significant number of elementary teachers have poor formal reasoning ability. Study done by Chiapetta (1976, cited in Tilgner, 1990) on the Piagetian operational levels of elementary education majors found more than 50% of elementary teachers in the study to be concrete operational. Tobin and Garnett (1984) investigated the formal reasoning ability of 299 pre-service primary teachers in Australia. They found that a significant number of these teachers did not use formal reasoning patterns in problem solving. They highlighted the importance of identifying the teachers with low formal reasoning ability and providing them with appropriate concrete activity in workshop situations. In another Australian study, Mulholland and Wallace (1996) described the experiences of five mature age pre-service teachers during the semester-long science education unit. All five teachers described themselves as visual, hands-on persons and had difficulties with abstract ideas. These teachers appreciated the activity-based workshops and demonstrations incorporated into the unit. These teachers described the hands-on activities as "interesting", "provided motivation", "get a better understanding', and "mean more to us personally".

It is argued here that teachers with poor reasoning abilities face problems in learning from instructional strategies such as lectures and books. Hands-on experiences and activity-based workshops would benefit them most to learn the basic science knowledge and skills. Moreover, such activities also help them move from concrete to formal operations (Tilgner, 1990). According to Tilgner, science courses which were lecture and note-taking with cookbook labs were of little benefit in terms of helping the teachers to provide hands-on science teaching in their classroom.

Teachers should have ways of learning science similar to how their students learn science. In other words, teachers should participate in the very process they would be teaching in their science lessons. As the students are to learn science concepts through inquiry learning, Tilgner (1990) suggested that teachers must be given the opportunity to learn science through inquiry to develop a meaningful understanding of the science concepts which they will be teaching and of the processes to be planned for their students. This can be achieved by involving teachers in hypothesising, experimenting, collecting, analysing data and other skills necessary in inquiry learning. Teachers must also be given the opportunity to address problems, issues, events, and topics that are important to science, the community, and the teachers (National Research Council, 1996). Tilgner believed that the more first-hand experiences the teachers could draw on, the better they would be in providing meaningful science activities for their students. Therefore, she advocated that science content courses should allow the teachers to interact with the environment in much the same way their students do and they should include work in life, physical and earth science. The National Research Council recommended that teachers should be provided with the opportunities to use scientific literature, media, and technology to broaden their knowledge, beyond the scope of immediate inquiries,

ii. Modelling and guided practice

There is general recognition that the majority of teachers experienced only didactic science pedagogy in their schooling and in their professional training. This has resulted in their conceptions of science teaching being primarily didactic (Stoddart, Connel, Stofflet, & Peck, 1993). In Harlen and Holroyd's (1997) investigation of Scottish elementary teachers' understanding of science concepts, teachers revealed their lack of understanding of what primary science should look like in action. These teachers expressed their need for someone to come into their classroom and show them how to do it. They asked for help with aspects of teaching, such as asking questions to stimulate their pupils' thinking, handling the questions pupils asked, and managing a class during practical work. Prather (1993) reported that hands-on science teaching which is the key component of student-centred instruction in science curriculum, is far from universally employed by teachers. Prather cited the finding of surveys carried out by Prather (1993) and Finson et al. (1993) where the majority of the teachers in both surveys expressed their need for more supervised practice before they could employ hands-on teaching methods in their classroom.

Hollon, et al. (1991) considered modelling and guided practice as absolutely essential before teachers were expected to make fundamental changes in their practices in using new instructional strategies. They compared the situation to that of a doctor who was expected to use a new surgical technique on his patient only after repeated demonstration and guided practice under the supervision of a specialist. Just as a doctor would not be expected to perform the surgery on his patient after reading about the technique or attending a seminar describing the procedure, Hollon et al. considered it unreasonable to expect teachers to use new instructional strategies by simply presenting them with information on these strategies.

Teachers need to see and experience for themselves the multiple ways of teaching if they are expected to use multiple ways of teaching in their classroom. Teachers should also experience the learning of content in conceptually-based classroom so that they could better teach for conceptual understanding (Stofflett & Stoddart, 1994). Yager and Penick (1990) considered it essential for teachers to experience how to inquire, how to find answers, how to use materials and human resources in order to teach these skills to their pupils. Modelling by the teacher educators can provide the teachers with these experiences. It is important for teacher educators to recognise that teachers have difficulty making the transition from being relatively passive students to being active, dynamic and thoughtful teachers. As mentioned in the preceding section, many teachers are concrete operational and lack formal reasoning ability. Therefore, it would be unreasonable to present teachers with ideas and principles and leave them to create the practical response.

Modelling or demonstration refers to instances where the course instructors take the role of teachers and the teachers take the role of pupils participating in activities designed for classroom. Yager and Penick (1990) suggested that teacher educators can consciously model questioning and responding behaviours and patterns, using a variety of techniques to make these planned behaviours overtly visible to the teachers. According to Constable and Long (1991), modelling or demonstration offers a practical expression of the ideas involved in an innovation, thus clarifying some of the nuances of ideas underpinning the proposed change. Constable and Long suggested that demonstration can also provide teachers with a means of mentally exploring the proposed change, anticipating the problems, raising questions about the innovation, and confronting the underlying principles behind the proposed change. Tilgner (1990) concurred that teacher educators should model an extensive and diverse assortment of activities to get the teachers acquainted with such activities to be tested in their classroom. In other words, they should model exemplary instructional design and practice in science teaching. Prather (1993) suggested that exemplary in-service teachers could constitute a ready and capable resource for enhancing teacher development. Video recording of these lesson exemplars can also be used.

iii. Conceptual change learning model

Any curriculum implementation will involve teachers in a process of learning new roles and unlearning old ones. Changes are required in teaching behaviour, as well as in beliefs, attitudes and understanding (Van Den Akker, 1988). Just as students have prior knowledge of various phenomena which they bring to the classroom, teachers have their own conceptions of the nature of science (Abell & Smith, 1994; Lederman, 1992), science discipline knowledge (Appleton, 1992), and teaching and learning (Hollon et al., 1991). Experienced teachers hold patterns of thought and action that have developed over many years (Hollon et al.; Wallace & Louden, 1992). Guatafson and Rowell's (1995) study revealed that Canadian pre-service elementary teachers' initial ideas about teaching and learning were predominantly influenced by their own learning preferences and a variety of experiences from their personal lives. Briscoe (1996) described teachers' knowledge constructions as both practical and context-bound, tested against the perceived reality of school experience. These typically well-grounded implicit theories and conceptions are robust and extremely resistant to change (Cronin-Jones & Shaw, 1992; Weinstein, 1989). Simply presenting new information as is often employed in teacher preparation programs has been found to have very little impact (Cruickshank & Metcalf, 1990; Weinstein, 1989).

Cronin-Jones (1991) revealed that teacher education programs rarely address the issue of pre-service and in-service teachers' prior knowledge. Instructors often assume that these teachers share the same beliefs as they themselves and therefore concentrate on planning, instruction and assessment issues. Dana, Campbell, and Lunetta (1997) described the various elementary science curriculum projects, including the Summer Institutes in the USA during the 1960s and 1970s as technical in nature, grounded in positivistic epistemology. In these projects, elementary teachers were viewed as lacking in important knowledge that could be remedied by experts, who could provide them with science content knowledge and information about how to teach the new curricula. This is based on the assumption that teachers equipped with knowledge of science and of pedagogy could effectively implement the change. Dana et al. reported that these deficit model courses did not have the effects in the classroom that had been envisioned.

Dana et al. (1997) suggested a productive model or non-deficit model (Paige, 1994) in which teachers are viewed as learners of science and science-related pedagogy, where their skills and knowledge are valued. Tillema (1995) suggested that diagnosis of teachers' preconceptions alone is not enough. Kagan (1992) recommended that a conceptual change model needs to be used in teacher education programs. Mulholland and Wallace (1996) described a constructivist approach to learning as the key to effective science education courses for teachers. They claimed that such an approach allows for learner dignity as well as the slow and deep development of concepts. Teachers' first-hand experience of a constructivist approach to learning will enhance their ability to use similar approach in their science teaching.

A conceptual change learning model, with hands-on activities and modelled practice, could be seen as an effective way to equip teachers with the necessary science content knowledge and pedagogical content knowledge to teach an-inquiry based science curriculum. However, this approach is time-consuming. This can only be done by covering less subject content. A slow pace of presentation and a gradual introduction of new ideas and terminology allows for a thorough exploration of ideas and activities, enabling teachers as learners to go beyond concrete experience to build abstract concepts (Mulholland & Wallace, 1996). This approach avoids the discouragement experienced by teachers who have been presented with too many new ideas at one time and end up with little understanding of these ideas. This is the case for covering less content but ensuring understanding, rather than trying to cover more content without proper understanding. It can be argued that once teachers have understood the underlying philosophy of the new curriculum, they would be able to access other content areas on their own (Appleton, 1995).

Training programs incorporating a constructivist theoretical underpinning have been found to be the most successful in increasing the confidence and competence of female primary teachers to teach science (Crawford & Zeegers, 1993 cited in Paige, 1994). Challenging beliefs and stimulating cognitive conflict as a confrontational approach to knowledge restructuring have more promising success than an incremental training approach aimed at the gradual accretion of new information and tuning of existing knowledge structures, at least where professional learners were concerned (Tillema, 1995).

This can also be applied to pedagogical knowledge, where teachers must undergo a process of conceptual change to change their views of science teaching (Stofflett, 1994). Teachers must be dissatisfied with existing beliefs and new beliefs must be intelligible and appear plausible before learning and behavioural change can take place (Posner et al. 1982). It is important for the teachers to make their views of teaching explicit, and to discuss and analyse these views critically. Aguirre et al. (1990) suggested that teachers should be provided with other views of science teaching and learning, and encouraged to reflect on these views and on their implications for science instruction. Many teachers do not have the opportunities to keep up to date with more recent researches in education. It is unlikely that these teachers have proper understanding of the recent developments in cognitive learning relating to matter such as learners' prior knowledge, situated learning, and conceptual change learning. As teachers' understanding of these ideas are critical in teaching science using an inquiry approach, teachers need to be introduced to these ideas. In the same way that constructivist teachers respected their students' alternative conceptions of science while encouraging them to be open to new ideas, the teacher educators should also value the alternative conceptions of science teaching and learning of the teachers, and be willing to consider other perspectives.

Mulholland and Wallace (1996) affirmed that changing attitudes toward science was an important step in breaking the cycle of the impoverished state of elementary science. Teacher educators should move away from a 'right-wrong' mentality, valuing all participants' contribution with their questions and answers as a starting point for their concept development.

iv. Didactic instruction

The benefits of the non-didactic approaches to deliver subject matter knowledge and pedagogical content knowledge to the science teachers should not be interpreted as lessening the importance of didactic instruction. Though no one should succumb to the use of lecture as the only instructional strategy in teacher education programs, no one can deny that lectures are one essential part of teacher training programs. McNamara (1990) challenged the view that critical thinking cannot be engendered in highly structured or didactic contexts. He argued that teachers must be taught explicitly how to become critical thinkers and that such teaching may need to be didactic. He cited another example where teachers need to be provided with clear guidance on what to observe and how the evidence of that observation could be built into diagnosis of learning problems in order for them to become aware of individual pupil differences.

In a study to investigate the implementation of cooperative learning and constructivism in primary science in Malaysia, Mohd Saat (1997) reported that none of the teachers used the Jigsaw method of cooperative learning despite having been exposed to the Jigsaw method. The Jigsaw method was used in conducting one of the in-service courses to provide a hands-on experience to the participating teachers in handling this method. However, during the course, the teachers were not informed of the method used and no theoretical background was given to them. Mohd Saat argued that teachers should be provided with some theoretical information related to cooperative learning and achievement, to go hand in hand with practical experience. Didactic instruction can be used to deliver the theoretical aspect dealing with studies done in the area of cooperative learning and achievement, such as the work of Johnson and Johnson (1990).

Teachers could learn the history, philosophy and sociology of science in order to better understand the nature of science, which includes the nature of scientific theories, scientific processes, and the progression and change of scientific knowledge (Brickhouse, 1990). Teachers possess a variety of views about the nature of science. It is important to make their views explicit and to provide them with other views about the nature of science as these have strong implications for science instruction.

Reconceptualizing the nature of science by teachers through discussions, readings and activities, will spark off discussion about scientific enterprise. The formal treatment of different views of the nature and philosophy of science in science teacher education programs would help address this concern (Aguirre et al., 1990). According to Lakin and Wellington (1994), this may not require detailed treatments of Popper, Kuhn or more recent views of science but does require a brief overview for teachers to recognise the gaps in their knowledge and awareness.

3.3.2 School-based teacher development

Fullan (1991) described curriculum implementation as a social process where constant communication and joint work provide the continuous pressure and support necessary for getting things done and teacher collaboration is seen as where the power for change begins. He regarded collaborative work cultures as central to reduce the professional isolation of teachers, allowing the codification and sharing of successful practices and the provision of support. Working together has the potential of raising morale and enthusiasm, opening the door to experimentation and increased sense of efficacy (Rosenholtz, 1989). Despite wide recognition of the importance of teacher collaboration, it remains a phenomenon that is not currently embedded within the cultures of most education enterprises. Fullan (1991) described the difficulty of being a lone innovator. He reported on teachers who find the course stimulating and note that it contains many valuable ideas, but when the individual teacher attempts to put the ideas into practice, there is no convenient source of help or sharing when problems are encountered.

This section describes five ways in which various support systems within and outside the schools can contribute to teacher development during the course of the implementation of a new curriculum. They are: (i) teachers' peer group collaboration, (ii) teacher-expert collaboration, (iii) teacher-policy maker collaboration, (iv) school-industry partnerships, and (v) teacher-administrator co-operation.

i. Teachers' peer group collaboration

Fullan (1991) considered collegiality among teachers within the school as a strong indicator of implementation success. Various studies have reported the benefits of collegiality and collaboration amongst teachers. Briscoe and Peters (1997) reported a study where teachers attended a three-week in-service project that focused on assisting teachers to implement the problem-centred science curriculum where collaboration effort was incorporated into the project. The study showed that collaboration facilitated change by providing opportunities for teachers to learn both content and pedagogical knowledge from one another, and encouraging teachers to be risk takers in implementing new ideas, thereby helping to support and sustain the teachers' change process in science teaching. It was reported that as these teachers began to implement problem-centred activities, they became learners with their children. In Rosenholtz's (1989) study, shared meaning among teachers characterised those schools that were continually improving. Silvester (1989) described peer interest and interaction between colleagues, such as observing other teachers at work and exchanging classes with other teachers, as being able to provide the most satisfying and effective aspects of the change process.

Teachers continually speak of learning from colleagues and sharing ideas with colleagues as major influences on their professional knowledge. Loughran and Ingvarson (1993) proposed that the work place should be restructured to capitalise on teachers' collegial learning. This requires special training for the heads of department as well as the development of materials, ideas and resources for running useful in-school programs for professional development. Silvester (1989) warned of the negative influence on the professional development of teachers by colleagues who were resentful of innovative and creative lessons. The energy and vision which new teachers bring to their work can be easily destroyed by cynical older teachers (Lacey, 1978, cited in Silvester).

Cole and McNay (1989, cited in Fullan, 1991) identified four major goals of induction programs for beginning teachers as orientation, psychological support, acquisition and refinement of teaching skills, and development of a philosophy of education. Just as the induction programs are important to ensure teacher quality for beginning teachers, similar programs should be provided for teachers who are required to implement a new curriculum. This is particularly so when the underpinning philosophy of the new curriculum is unfamiliar to the teachers. Huling-Austin (1990) cautioned that desired outcomes are rarely achieved by accident. It is therefore important that program activities specifically targeted towards identified outcomes must be carefully designed and implemented appropriately to ensure the success of the program.

Collaboration involves teachers concentrating on individual strengths and using working relationships to combine resources to overcome constraints such as time, lack of materials and lack of ideas (Briscoe & Peters, 1997). Interaction with their peers provides them with multiple opportunities for learning both content and pedagogy that would support their teaching. The extent of the science curriculum is broadened as teachers begin to teach science in a manner previously avoided due to lack of knowledge. Free discussion and sharing of ideas, frustrations and constraints, help the teachers to lessen the fear of risk-taking. Laderwski, Krajcik, and Harvey's (1994) study suggested that teachers' collaboration with peers provides new strategies and feedback concerning what works and does not work in classroom, as well as collegial acceptance and support for trying out new ideas.

Study done by Lewis and Tsuchida (1997) suggested that research lessons had helped Japanese elementary teachers to successfully move from teacher-centred 'teaching as telling' towards student-centred 'teaching for understanding' in science instruction. Here, a research lesson refers to one which is often prepared by a group of teachers working collaboratively, taught by one teacher but observed by many others. Lewis and Tsuchida described in-school research lessons as "a regular, ubiquitous feature of life at elementary schools throughout Japan, occurring as frequently as several times a month, or as infrequently as several times a year" (p.321). Japanese elementary schools also offer public research lessons several times a year where these lessons are open to teachers from other schools. According to them, as teachers plan and conduct research lessons, they not only construct a concrete understanding of abstract goals such as 'problem-solving capacity' and 'autonomous learning', they also help each other develop the specific techniques and materials needed to bring these ideas to life in classroom practice. Furthermore, through the shared concrete research lessons, teachers with different views of learning exchange ideas, define collectively what innovations mean, and how education's many goals can be achieved. Research lessons provide opportunities for teachers to work and learn together both before and after the lessons.

Teachers could form collegial groups, such as study groups or professional networks such as science-teaching associations, state and local organisations, and telecommunications networks, which could provide safe and rich learning environments in which teachers can share resources, ask and address hard questions, and continue to learn (National Research Council, 1996).

ii. Teacher-expert collaboration

Hollon et al. (1991) reported the encouraging success of projects which provided the environments where teachers and university faculty could come together to develop teaching skills, to examine new curricular resources and instructional strategies, and to participate in discussions of enduring problems of practice. Thus, individuals can experiment with new approaches to teaching without fear of collegial or administrative disapproval and with support from other teachers and university faculty.

Toh, Yap, Lee, Springham, and Chua (1996) documented how a partnership between teachers and academics could win over the teacher collaborators to the pedagogical advantages of moving away from the transmission-oriented approach of science teaching and learning to shift towards a transaction-oriented approach. These 'prestigious outsiders' could provide a valuable source of encouragement through input of non-intrusive comments and advice, representation of the group's endeavours to other people in positions of power, and by providing information from research sources or about the work of other teacher-groups (Claxton & Carr, 1991). Collaboration with university staff provides the teachers with new information on theoretical background, content, and activities (Ladewski et al., 1994).

iii. Teacher-policy maker collaboration

Studies in curriculum implementation have indicated that implemented curricula were often quite different from intended curricula. Cronin-Jones (1991) suggested that teachers significantly altered intended curricula to make them more congruent with their own teaching contexts and belief systems. Prather (1993) attributed this to the lack of involvement of classroom teachers in the planning of curriculum implementation which precluded the development of a general sense of ownership among teachers. Cronin-Jones suggested that the way to overcome this is to solicit more input from a wide range of teachers during all phases of curriculum development. Existing teacher belief structure needs to be taken into consideration in the development of any new curricula so that the intended curricula are more congruent with the real world teaching context.

iv. School-industry partnerships

There seems to be increasing recognition of the value of education-industry links and partnerships. Farrell (1992) found that teachers looked for mathematics and science applications in industry which they could take back to their classroom. These teachers adapted their teaching methods to include more teamwork, problem solving and communication exercises in order to prepare students better for careers in business and industry. Fanning and Fanning (1993) reported that chemistry teachers developed a better understanding of the environmental problems being faced by industry and the ways these are solved. Ball, Jones, Pomeranz, and Symmington (1995) described the many benefits of the Teacher Release to Industry Program (TRIP) to the teachers involved. These included (i) changing teachers' conceptions of professional development, (ii) enhancing teachers' management, organisation, interpersonal and communication skills, (iii) widening teachers' views on a variety of issues, and (iv) changing their views on the nature of schools as work places.

All these studies of teacher industry placements reported of teachers being highly motivated by such experience. Generally, teachers benefit a great deal from this exposure to organisations whose goals, climates and processes are somewhat different from those of schools. Over the last decade, many science curriculum have advocated the use of contexts such as everyday experience and real issues as platforms to learn science. However, many teachers are unable to provide such contexts due to their own lack of exposure and awareness. Thus, the education-industry partnership could provide the teachers with valuable experiences of these contexts, thus enabling them to employ these contexts in their science teaching.

v. Teacher-administrator co-operation

Teacher development does not take place in a vacuum. Its success is influenced in many ways by organisational factors which include the institutional climate, leadership attitudes and behaviours, and involvement of teachers (Sparks & Loucks-Horsley, 1990). Institutional constraints have been cited as obstacles to the translation of teachers' beliefs into instruction. Sparks and Loucks-Horsley described organisations where staff development is most successful as those where the administrators exercise strong leadership by promoting a norm of collegiality, minimising status differences between their staff members and themselves, promoting informal communication, and reducing their own need to use formal controls to achieve co-ordination. Teachers cannot be expected to engage in professional growth and development in an environment that fails to provide both the innovation and the tolerance of some ambiguity that are needed to foster change (Hollon et al., 1991). "The success of professional development for practising teachers is heavily dependent on the organisational dynamics of schooling, such as a climate that permits change and risk-taking, good relationships among school personnel, communication structures, and an appropriate distribution of authority" (National Research Council, 1996, p.71). This involves the commitment of the administrators and other school staff to ensure that the teachers are supported and integrated into the ongoing life of the school. In everyday teachers' lives, teachers are always short of time. The crowded nature of the school day offers every obstacle for the teachers to meet within school hours regularly and consistently, to discuss their different professional and personal perspectives. Pervasive hierarchies are also found to inhibit discussion. Sparks and Loucks-Horsley commented that teachers are more likely to persist in using new behaviours in schools where collaboration and professional risk taking are encouraged. Miles (1983) regarded teacher-administrator harmony as critical to the success of improvement efforts.

Fullan (1991) considered the principal as the key to creating the conditions for the continuous professional development of teachers. According to Barth (1990 cited in Fullan, 1991), "the teacher-principal relationship should be that of helpful. supportive, trusting, revealing of craft knowledge and not one of suspicious, guarded, distant, adversarial, acrimonious or judgmental" (p. 19). The National Research Council suggested principals should participate in professional development activities in order to increase their own understanding of student science learning and of the roles and responsibilities of teachers. Mechling and Oliver (1983) proposed that science curricula should be introduced to principals as well as to teachers. Principals should in fact be the prime audiences for in-service education (Fensham, 1985). Mechling and Oliver reported instances of principals who have participated in science in-service programs having become science leaders, continually monitoring and analysing the science curricula, providing in-service training, and acting as trouble-shooters. Hord and Huling-Austin (1986) reported of a principal who organised a task force of parents who prepared supplementary materials kits for teachers to use in the new program. They also personally observed one principal who provided ongoing staff development sessions that he conducted himself as part of the weekly faculty meetings, addressing teachers' needs as they emerged.

The principals can also boost the teachers' morale by showing appreciation for teachers who show enthusiasm, innovation and participation (Claxton & Carr, 1991). In a literature review on teacher change, Silvester (1989) suggested that principals could encourage teacher change by creating a positive climate, through providing support in the form of encouragement, resources and time for professional development. Tilgner (1990) suggested that other supports in the form of supplies, in-service training for the teachers, and developing contacts in the community to provide science enrichment activities. Principals could also look into the possibility of a technician to help ease the workload of the teachers, as Harlen and Holroyd (1997) reported of teachers who had to spend hours searching, collecting and checking equipment to prepare a single session of practical work. On a different note, Huberman (1983) reported that administrators' strong and continuous pressure for implementation ensures teachers' successful use of new skills. He argued that administrators have to go to centre stage and stay there if school improvement efforts are to succeed.

3.4 Implementation of Malaysian Primary Science Curriculum

Snyder, Bolin, and Zumwalt (1992) described curriculum implementation from three perspectives: (i) a fidelity perspective; (ii) a mutual adaptation perspective; and (iii) an enactment perspective. From the fidelity perspective, curriculum knowledge is primarily created outside the classroom by curriculum experts for teachers to implement in the way the experts have decided as best. Here, a structured approach is used whereby teachers are given explicit instructions on how to teach a unit, and little provision is made for the various school contexts in which the unit might be taught. Mutual adaptation involves negotiation and flexibility on the part of both the curriculum developers and teachers. Adherents of the mutual adaptation perspective maintain that differing organisational contexts and teacher needs will require on-site modifications (Lighthall & Allan, 1989). The role of the teacher becomes more central because their input in shaping the curriculum is required if the curriculum is to be successfully implemented in the particular setting. From the enactment perspective, the role of the teacher is that of a curriculum developer where teachers and students are creators rather than primarily receivers of curriculum knowledge.

Externally created curricular materials and programmed instructional strategies are viewed as resources for teachers who create the curriculum.

Malaysia has a mandatory national curriculum for all secondary and primary schools throughout the country. Implementation of such mandated curricula may be anticipated to adhere closely to the curriculum developers' intentions which is in line with a fidelity approach. Malaysian primary teachers only possess secondary school qualifications and have undergone two years of pre-service teacher education. As such, most of them lack the curricular literacy which is required for the confident critique and adaptation of materials. Their lack of curriculum interpretative skills, their dependency on the curriculum developers' knowledge and expertise, and centralised examinations are among the key factors which cause many teachers to adopt the fidelity perspective in the choice of subject content.

However, as the new primary science curriculum guidelines do not offer detailed descriptions of content, time allocation and instructional strategies, teachers have no choice but to adopt mutual adaptation perspective. Teachers have to interpret and transform the mandated curriculum materials into concrete learning experiences within the complexities of their classrooms, based on their subject content knowledge and pedagogical content knowledge. The initiation processes involved in the implementation of Malaysian Primary Science Curriculum are listed in Appendix B. The main processes involving teacher preparation, preparation of curriculum materials, supply of science equipment, and the management of assessment system, are described in the following sections.

3.4.1 Teacher preparation

Both in-service and pre-service teacher education programs were conducted to equip practising teachers and student teachers respectively with the knowledge and skills required to implement the Malaysian Primary Science Curriculum.

In-service science teacher education program

PPK within the Malaysian Ministry of Education conducted a series of three orientation courses on the new primary science curriculum for practising teachers. The three orientation courses were for Primary Four, Primary Five, and Primary Six respectively. According to Mohd Saat (1997), the main aim of these courses was to introduce the new curriculum and refresh the teachers with various approaches, teaching-learning strategies and some science content, bearing in mind that they have undergone all these aspects during their teachers' training. A total of 14,000 teachers were trained in this exercise, involving an average of two teachers from each of the 7,000 primary schools in Malaysia. A cascade approach was adopted whereby 438 science resource teachers from the 13 states in the country were selected to attend a one-week course at the national level (Ministry of Education, Malaysia, 1993d). These resource teachers conducted similar courses for the teachers at state and district level, with at least one teacher from each school. Each of the participating teachers was given a set of the curriculum materials. In turn, these teachers were required to run in-house training for the rest of the science teachers in their respective schools.

The content of the three orientation courses was based on the twelves modules prepared by PPK. The Primary Four Orientation Course was based on Modules 1-5 (Ministry of Education, Malaysia, 1994a, 1994b, 1994c, 1994d, 1994e); the Primary Five Orientation Course was based on Modules 6-8 (Ministry of Education, Malaysia, 1995a, 1995b, 1995c) and the Primary Six Orientation Course was based on Modules 9-12 (Ministry of Education, Malaysia, 1996a, 1996b, 1996c, 1996d). All modules are available in Bahasa Malaysia only. See Appendix C for a brief description of each of these modules.

Table 3.2 shows the timetable for the Primary Four Orientation Course for the resource teachers. It shows the time allocation on the various aspects of the curriculum such as introduction to the curriculum, the organisation of the primary science curriculum, scientific skills, thinking skills, scientific attitudes and moral values, teaching-learning strategies, and workshop sessions on lesson planning. During the course for the resource teachers where the researcher was an observer, a hands-on approach was prominent. Here, the resource teachers carried out most of the activities in the modules. They were required to use a similar approach in conducting the course for the teachers in their respective states or districts. Primary Five and Primary Six Orientation Courses were organised in similar patterns.

Pre-service science teacher education program

In conjunction with the implementation of the new primary science program, the Teacher Training Division began to offer a science major in the pre-service primary teacher education program starting June 1993 (Ministry of Education, Malaysia, 1993d). Pre-service primary teacher education program is a three-year course which spans over six semesters. Table 3.3 shows the various components of the primary

Table 3.2: Primary Four Science Orientation Course Timetable

	0800-1000	1030-1230	1400-1600
Day 1	Opening ceremony Briefing on the role of the resource teachers	Education vision	Introducing the science curriculum (I) About science
Day 2	Introducing the science curriculum (II)	Scientific skills (I)	Scientific skills (II)
Day 3	Thinking skills	Scientific attitudes and moral values	Teaching-learning strategies (I)
Day 4	Teaching-Learning strategies (II)	Workshop: Preparing lesson plans (I)	Preparing lesson plan (II)
Day 5	Presentation of lesson plan and micro teaching (I)	Presentation of lesson plan and micro teaching (II)	Presentation of lesson plan and micro teaching (II)
Day 6	Refinement of lesson plans	Dialogue session Closing ceremony Certificate presentation	

science education program for each of the six semesters for those majoring in science (Ministry of Education, Malaysia, 1997b). Besides specialising in their major(s), student teachers are also required to take courses in Bahasa Malaysia, Moral Education or Islamic Studies, Information Technology, Psychology, Pedagogy, Co-Curriculum, Counselling and Guidance, and Critical and Creative Thinking.

The science education program consists of three components, (i) academic, (ii) pedagogy, and (iii) practicum. The academic component which consists of the science content knowledge occupies 300 hours out of the total allocated time of 480 hours of the course. This component is designed to provide the student teachers with adequate and appropriate background understanding of the various science concepts to teach primary science as it should be taught. However, while many of these concepts are dealt with in much greater depth than is necessary to be able to teach primary science, a number of the basic concepts applicable to the primary science curriculum have not been included. For example, for 'Animal Reproduction', student teachers are required to learn about fission and budding, to understand the meaning of meiosis, and to make observation on cross-section of slide preparation of testes and ovaries. These concepts are not taught in the primary science curriculum. Student teachers are not introduced to concepts taught in the primary science curriculum which include complete and incomplete metamorphosis of insects, the differentiation

Table 3.3: Syllabus Content of the Pre-service Primary Science Teacher Training Program in Malaysia

Content	S1	S2	S3	S4	S5	S6
1. Academic Component						
Living world:						
Diversity of living things	30 hr.					
Life processes		30 hr.				
Interaction between living things			15 hr.			
Physical world:						
Measurement and movement	30 hr.					
Energy		30 hr.				
Electricity and magnet			30 hr.			
Material world:						
Matter and materials	30 hr.					
Variety of materials		30 hr.				
Reactions between materials			30 hr.			
Universe and Technology:						
Earth and the universe				30 hr.		
The world of science and technology					15 hr.	
2. Pedagogy:						
Science curriculum	15 hr.					
Science teaching and learning strategies		30 hr.				
Micro-teaching and science process skills			30 hr.			
Science laboratory and teaching resources management				30 hr.		
Assessment and macro-teaching					60 hr.	
Science curriculum management						15 hr.
Total (in hours)	105	120	105	60	75	15
3. Practicum:	1 wk	4 wk	7 wk	8 wk	5 wk	12 wk

of male and female animals, various types of eggs, the gestation periods of animals, and the care of young animals.

The main strategy suggested in the syllabus for the student teachers to learn the science concepts is through the use of multimedia courseware to find information on various topics. Direct field and laboratory experiences to investigate phenomena which they are encouraged to use in their teaching, are generally lacking. For example, for the topic on animal movement, student teachers learn about the different types of animal movement. They also learn about the functions of muscles, ligaments and tendons, and the different types of joints in man. The use of the Internet has been suggested in the pre-service syllabus to obtain information pertaining to movements of different animals, while there is no mention of strategies relating to observations of the body parts involved in the movement and on how different animals move. Facilities such as the Internet are only available in the teachers training colleges and a small number of schools. The lack of field and laboratory activities in their learning processes reduces the student teachers' contact with the kinds of facilities, equipment, and library materials which are available in most schools. There is also no reference to student teachers' prior knowledge of these science concepts.

In the pedagogy section of Malaysian pre-service primary science education, student teachers learn about learning theories based on Piaget, Bruner, Ausubel and Gagne, and to compare them with the behaviourist learning theories. They also learn various learning models based on constructivism such as Osborne's Generative Model, Biddulph's Interactive Model, and Kolb's Learning Cycle. Student teachers are also introduced to the use of experiments, simulations, projects, field work and computer software in the teaching of science. Though the content organisation of this section is in line with the current development in science education, the instructional strategies used to present such information remain very traditional. In this case, it is done through direct instruction, discussion, followed by the writing of lesson plans. Student teachers' preconceptions of the nature of science and effective science teaching and learning are not made explicit in the syllabus.

Student teachers undergo practicum experiences in schools at different stages of their training. The aim of these experiences is to ensure that there is practice and direct experience to apply the theory learnt in the lectures in the context of the reality of the classroom.

3.4.2 Curriculum materials and other resources

Resource teachers are also required to play the role of facilitators in their respective districts, holding regular discussions with the science teachers. Training packages in the form of twelve modules mentioned in the preceding section (see Appendix C for details) were used, in an effort to minimise dilution and distortion that is likely to occur during such a cascade model of in-service training. These modules are in Bahasa Malaysia only. PPK has also published various curriculum materials which include the syllabus guide, textbooks, and teachers' guides. These are available in Bahasa Malaysia, Tamil and Chinese. While teachers in all schools use the same syllabus guide, the content of the pupils' textbooks and the teachers' guides in Bahasa Malaysia, Chinese and Tamil versions differ considerably.

The Ministry of Education allocated funding to alter one classroom in every primary school into a science room with a built-in cabinet and a sink, at an estimated cost of RM4,000. In addition, each school was supplied with a minimum of one set of the science equipment and materials (Ministry of Education, Malaysia, 1994f) costing RM3,600 through a central contract. In addition, a grant per capita of RM6.00 per pupil per year was also allocated to each school. The Ministry of Education approved a total allocation of RM100,801,784.00 (approximately NZ$50,000,000.00) to cover the expenditure incurred during the three-year period 1994-1996 of implementation. Table 3.4 shows the amount of money allocated to each type of expenditure involved.

Table 3.4: Expenditure Incurred during the Implementation of the Malaysian Primary Science Curriculum (1994-1996)

Activities	Estimated cost
1. Preparation of curriculum materials for 3 years @ RM72,230.00 a year	RM 207,320.00
2. In-service courses for 3 years @ RM1,331,488.00 per year	RM 3,994,464.00
3. Grants for pupils for 3 years @ RM2,600.00 X 7,000 per year	RM 54,600 000.00
4. Science rooms and equipment (RM 6,000.00 X 7,000)	RM 42,000 000.00
Total	RM 100,801,784.00

3.4.3 Assessment

Primary six pupils are required to sit for UPSR assessment. For science, they have to sit for two papers. The first paper which is the practical work assessment also known as 'Penilaian Kerja Amali' (PEKA) is school-based. Pupils are to be assessed on eight science process skills and five manipulative skills. The science process skills include observing, classifying, measuring and using numbers, communication, using space-time relationship, defining operationally, controlling variables, and experimenting. The manipulative skills cover their ability to use and maintain science equipment, materials, and living and non-living specimens. This is an attempt to bring closer together the assessment system and the new curriculum objectives which address the content as well as the science process skills, manipulative skills and scientific values. The second paper is a centralised written examination consisting of 30 multiple-choice questions and 5 structured-questions.

3.5 Summary

At this stage, the pitfalls of curriculum implementation are reasonably well known, and various factors associated with successful curriculum implementation have emerged. These can provide a source of ideas for implementation of any new curriculum. Implementing a new curriculum is a very complex process and there are no short cuts. Like most complex endeavours, in order to get better at it, it has to be approached purposefully. No single type of assistance is sufficient to ensure the success of the implementation. Rather, a combination of different types of assistance have to be provided over a period of time.

To ensure the successful implementation of an inquiry-based science curriculum, teachers' views and knowledge of science education should be congruent with those advocated in the curriculum. This can be done through pre-service and in-service courses. The content of these courses and the pedagogy used in the delivery of the content should provide teachers with concrete experiences and role models. These teachers can in turn plan relevant activities and act as role models for their pupils to be engaged in inquiry learning during the science lessons. Ongoing support through well-organised staff development programs within the schools is necessary to facilitate teachers to put theory learned into practice in their classroom. In addition, well-designed curriculum materials and valid assessments have also been highlighted as important factors facilitating the curriculum implementation process. Sensitivity towards cultural context of learning is needed in planning various teaching and learning strategies especially when the espoused mode of learning in a curriculum seems to be in conflict with what is propagated by the society. Teachers, teacher educators, curriculum developers, resource teachers, school administrators, and community members all have important roles to play in constructing the long-term institutional and societal support that is very much needed in successful curriculum implementation.

The Malaysian Primary Science Curriculum was in its third year of implementation at the time of this study. It was an appropriate time for science educators and policy makers to study the extent to which the curriculum has actually been implemented in the classroom and the extent to which teacher preparation, the support system, the curriculum materials, the resources, and the assessment system have facilitated the implementation of the new curriculum. This research explores these issues and asks questions about whether the criteria established as the essential ingredients for successful curriculum implementation have been addressed in the course of implementation. As this is a review of literature based mainly on Western classrooms, its relevance to the Malaysian classroom context needs to be considered with caution. Factors such as difference in the school culture and number of students in the classrooms must be taken into account when comparisons are made between the Malaysian context and those in the literature review.

CHAPTER FOUR
RESEARCH METHODOLOGY

This chapter describes the research methodology used in the study. It begins with the statement of purpose for the study leading to the research questions. The researcher then argues why a case study approach is appropriate for the study. This is followed by descriptions of selection of the research participants, data collection techniques, and data analysis. The research procedure, ethical issues, validity and reliability of the study are also discussed.

4.1 Statement of Purpose and Research Questions

The purpose of the study is to investigate the factors which influence the Malaysian primary teachers' science classroom practices during the implementation of the new inquiry-based science curriculum. The study explores the extent to which five Malaysian teachers in two primary schools implement this curriculum. It aims to gain an in-depth understanding of the factors which influence the teachers' classroom practices during science lessons in order to make relevant recommendations to improve the quality of primary science education in Malaysia.

The purpose of the study as stated above gave rise to the following research questions:

1. What are the teaching practices of five Malaysian primary case study teachers in their science lessons?
2. What are their understandings of the Malaysian primary science curriculum?
3. What are their conceptions of science teaching and learning?
4. What are the problems faced by these teachers in implementing the primary science curriculum?
5. To what extent have these teachers implemented the Malaysian Primary Science Curriculum?

4.2 Research Design: The Case Study Approach

Though the case study approach has been used extensively in the medical and legal professions and in fields such as anthropology, sociology, psychology and political science for a long time (Borg & Gall, 1983), case study as a method of investigation in education only became popular in the 1960s and 1970s (Merriam, 1988). Merriam described case studies as where the researcher explored a single entity or phenomenon called ‘the case’ by using a variety of data collection procedures during a sustained period of time. Yin (1994) contended that a case study is an empirical inquiry that “investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and content are not clearly evident” (p.13).

Merriam (1988) identified four properties of case study as particularistic, descriptive, heuristic and inductive. Its particularistic property focuses on a particular situation or phenomenon while the descriptive property refers to the nature of the end product, which is usually a detailed description of the phenomenon under study. The heuristic property is concerned with illuminating the reader’s understanding of the phenomenon under study, while the inductive property indicates its reliance on inductive reasoning.

Although case study has disadvantages in terms of the time-consuming nature of the data collection, data processing, reporting of the results, and the inability to generalise about conditions beyond the situations studied (Merriam, 1988; Yin, 1994), it offers the advantage of being able to provide insight and rich details into the actions and purposes of individuals (Schoeneberger & Russell, 1986) voiced by participants in a particular context (McMillan & Schumacher, 1997).

The main purpose of this study is to understand the factors which influence the teachers’ classroom practices during the implementation of an innovation in the context of classroom realities. The nature of the research problem and the research questions of the study naturally render the case study approach as a suitable research design. In this study, case studies were used to gain an insight into the teachers’ perspectives about curriculum and classroom instruction. It also provides an accurate portrayal of the realities of teaching in its natural settings, something that cannot be attained in studies using other research designs.

The data in this study reflect on only five teachers’ experiences of science teaching in two urban schools, and therefore are not conclusive in any way. It is important for the readers to recognise that in this study, the researcher did not aim at generalisation of results. After all, as Stake (1994) put it, “The purpose of case study is not to represent the world, but to represent the case” (p.245). The intent is to provide for extension of the findings that enables others to understand similar situations and apply these findings in subsequent research. In McMillan and Schumacher’s (1997) words, “Knowledge is produced not by replication but by the preponderance of evidence found in separate case studies over time or in more structured quantitative designs" (p.411).

4.3 Sample Selection

In contrast to probability sampling, purposeful sampling is "selecting information-rich cases for in-depth study" (Patton, 1990). According to McMillan and Schumacher (1997), the power of purposeful sampling is that a few cases studied in depth yield many insights about the topic, while the logic of probability sampling depends on selecting a random or statistically representative sample for generalisation to a larger population. In purposeful sampling, samples are chosen because they are likely to be knowledgeable and informative about the phenomena the researcher is investigating. In this study, the purposeful sampling was used in the sample selection to explore the teaching practices of experienced teachers in high performance schools. These cases were chosen because they were likely to provide some worthwhile experiences to be learned from their innovation and practices. Generally, experienced teachers would have mastered the skills in class management and are able to devote more time and effort to atttend to their teaching practices in accordance with the requirements of the new curriculum. Urban schools were chosen as they are comparatively well-resourced with materials and equipment.

The curriculum implementation process was explored in two different school settings, involving five teachers. This was considered feasible considering the time available to complete the field work. Three months is the standard time period granted by the Malaysian Ministry of Education to enable its scholars to complete field work in Malaysia.

4.4 Participating Schools

As mentioned earlier in Chapter One, there are three types of primary schools in Malaysia, (i) SK/SRK, (ii) SRJK(C), and (iii) SRJK(T). These schools follow the same national curricula. SK/SRK are National Schools where the medium of instruction is Bahasa Malaysia. SRJK(C) and SRJK(T) are National-Type Schools where the medium of instruction is Chinese and Tamil respectively. There was no SRJK(T) in Sabah, and moreover, the researcher was incompetent in Tamil. A SRK and a SRJK(C) were selected for the study. Hereafter, the two schools are referred to as St. Elizabeth Primary School and Sin Hwa Chinese Primary School respectively. Both names are pseudonyms. Table 4.1 shows the composition of the two schools while Table 4.2 shows the schools' UPSR performance over the past three years (1994-1996).

Both schools were high-performance schools based on their past three years UPSR performance. The two schools were located in a suburban area of a major town in the state of Sabah. Their proximity allowed the researcher to travel between the schools on the same day. The average socio-econmic status of the pupils in the two schools was similar. Sin Hwa School is a co-educational school whereas St. Elizabeth School is a girls' school. Though many Western science curricula take into account the gender issue regarding girls' interests with relevance to science learning, this issue is less prominent in Malaysian science curricula. This is apparent as there is no reference to gender differences in the science curricula or for that matter in the other curricula.

Table 4.1: Characteristics of Participating Schools

	Sin Hwa Primary School	**St. Elizabeth Primary School**
School type	Chinese	Bahasa Malaysia
Locality	Sub-urban	Sub-urban
Pupil enrolment	2467 (1195 girls; 1272 boys)	1130 (all girls)
No. of teachers	79 (71 female; 8 male)	53 (49 female; 4 male)
No. of science teachers	17	4
No. of classes	48 (32 - morning session; 16 - afternoon session)	25 (13 - morning session; 12 - afternoon session)
Average number of pupils per class	50	50

(Source: Head teachers' questionnaire)

Table 4.2: Participating Schools' UPSR Performance (1994-1996)

	Sin Hwa School		**St. Elizabeth School**	
	Number of pupils	Percentage pass	Number of pupils	Percentage pass
1994	378	61	185	87
1995	357	72	187	91
1996	384	73	187	91

(Source: Information provided by the head teachers)

4.5 Research Participants

The participants of the study were the five teachers and the two head teachers. All participants are identified by pseudonyms. The teachers were Mrs. Chan and Mrs. Lim of Sin Hwa Chinese Primary School, and Pn.[1] Fatimah, Pn. Christina and Pn. Jane of St. Elizabeth Primary School. As shown in Table 4.3, they represented a diversity in years of teaching experience and science background. Their teaching experiences ranged from 9 to 32 years. While two of the teachers had studied pure science during their school days, the remaining three teachers had exposure to general science only. All of them were trained teachers and had some experience in teaching science or 'Man and His Environment' prior to teaching the new primary science curriculum. The teachers happened to be all female which is not surprising as the number of male teachers in both schools was less than 10 per cent.

Table 4.3: Participating Teachers' Profiles

	Mrs. Lim	**Mrs. Chan**	**Pn. Fatimah**	**Pn. Christina**	**Pn. Jane**
Age (years)	36-40	over 50	41-45	25-30	31-35
Teaching experiences (years)	19	32	22	9	12
Academic qualification	School Certificate	School Certificate	School Certificate	School Certificate	School Certificate
Professional qualification	Teacher Certificate	Teacher Certificate	Teacher Certificate	Teacher Certificate	Teacher Certificate
Highest science qualification	Biology, Chemistry, Physics	Biology, Chemistry, Physics	General Science	General Science	General Science

(Source: Teachers' questionnaire)

Criteria set by the researcher and made explicit to the head teachers included a minimum of five years of teaching experience, and that they were considered to be reasonably good teachers. As it turned out, the least experienced teacher has nine years of teaching experience. This study involved the use of semi-structured interviews where the teachers were required to express their perceptions and understandings of various aspects of science education as well as to clarify and justify

[1] A Malay woman retains both her first name and her surname when she gets married. However her title changes from 'Cik' (Miss) to 'Puan' (Madam) which is often abbreviated as 'Pn.'. Nowadays, it is common for married women of other ethnic groups in Malaysia to retain their full names and refer themselves as 'Puan' instead of 'Mrs.'.

what they did in their science lessons. Therefore, teachers' clarity of expression, their frankness, and their ability to articulate their thinking would be essential to enhance the quality of these interviews. These characteristics were also made known to the head teachers.

The other participants of this study were the Head Teachers of the two schools, referred to as Mr. Ong of Sin Hwa Chinese Primary School and Pn. Doris of St. Elizabeth Primary School.

4.6 Data Collection Techniques

An eclectic approach using different techniques was used in this study to obtain the necessary data to address the research questions. These techniques included observation, interviewing and document analysis. Multiple sources of information are used because no single source of information can be trusted to provide a comprehensive perspective (Patton, 1990). A combination of observation, interviewing and document analysis not only allows for a holistic interpretation of the phenomenon being investigated (Merriam, 1998) but also enables the researcher to validate and cross-check findings (Patton, 1990).

Data collection was undertaken mainly through classroom observations and in-depth interviews with teachers. Interviews with teachers were designed to provide further insight and information about teachers' classroom practices to provide meaning to their observed practices. Data from the head teachers' interviews and documents were used to provide support or contrasts to what the teachers said and did. Thus, these data collection techniques provide a rich source of information on teachers' personal understandings of science teaching and learning, their perceptions of the problems and how these perceptions influenced their classroom practice. Head teacher and teacher questionnaires were used to provide demographic data only.

4.6.1 Observation

Participant observation ranges across a continuum from complete observer to complete participant (Glesne & Peshkin, 1992; Merriam, 1998). At the complete observer end of the continuum, the researcher observes behaviours of subjects through one-way mirrors while at the other end of the continuum, the full participant researcher is a fully functioning member of the group being studied. In between the two extremes are the observer as participant and the participant as observer.

The role of the researcher in this study, came close to being a complete observer or a non-participant observer. In Wolcott's (1990) term, the researcher engaged in privileged observation, where permission to observe was sought. This was because Malaysian teachers generally do not feel comfortable about the idea of any adult sitting in their lessons. They are occasionally observed by their head teachers and by school inspectors, who come to evaluate their teaching. These teachers have kindly consented to participate in the study despite their initial apprehension about their involvement. In consideration of the teachers, the researcher tried to remain as unobtrusive as possible so as not to make them feel that they were being intruded upon or being evaluated.

The unit on 'Animal reproduction' was selected for observation for all five teachers as this unit was on all the teachers' plan during the period of the study. This was agreed upon by the teachers. All lessons were videotaped by the researcher. A video camera, fitted with a wide-angled lens, was set up at one corner at the back of the classroom to take in all the pupils in each class. The researcher's task was mainly to zoom in and out the lens whenever necessary. As all the teachers did not use any specimens in teaching animal reproduction, the researcher was wondering how these teachers would actually handle a science practical lesson. A request was made to the teachers to teach a science lesson involving practical activities. The two teachers in Sin Hwa School told the researcher that the observed lessons were quite typical of their other lessons, and therefore no addition lessons were observed. The three teachers of St. Elizabeth agreed to the researcher's request. Pn. Jane and Pn. Fatimah taught a lesson on flower pollination where the pupils brought in hibiscus flowers while Pn. Christina taught a lesson on measuring heat using a thermometer. These lessons were also videotaped.

As there were no clashes in the teachers' timetables for these lessons, all the teachers taught their lessons as they were in their original timetable. They were frequently reminded that the researcher's intention was not to evaluate their teaching but rather to see what was actually happening in their science lessons. They were encouraged to teach the lessons as they would have taught in the absence of the researcher. When it became obvious that the first teacher observed was not going to use any other teaching aids besides charts, the researcher decided to look for some teaching aids from the Sabah State Education Department Resource Centre. Eventually, the researcher borrowed the following materials and equipment and handed these over to the teachers. They included:

1. a set of slides showing various marine mammals,
2. a video recording of an education program showing animal reproduction,
3. a chart containing various developmental stages of a chick from the egg, and
4. a slide projector.

These materials and equipment were offered to all the five teachers. The researcher made known to the teachers that they could choose to use or not to use the materials provided.

Besides the classroom observations, the researcher also obtained the Head Teachers' permission to attend one assembly in each of the schools. These observations were not taped but field notes were taken.

4.6.2 Interviews

The interview technique involves data collection through direct verbal interaction between individuals. Interviewing allows the researcher to gain insights into others' perspectives about the phenomena under study. It is particularly useful for ascertaining respondents' thoughts, perceptions, feelings and retrospective accounts of events (Goodwin & Goodwin, 1996) as these things cannot be directly observed (Merriam, 1998; Patton, 1990). Various ways of categorising interviews are found in the literature. Fetterman (1989) categorised interviews into four general types: structured, semi-structured, informal and retrospective. Patton's four categories included closed field response interview, standardised open-ended interview, interview guide approach, and informal conversational interview. Many research reports use categorisations such as structured versus unstructured, focused versus unfocused, limited versus in-depth, and formal versus informal as the two ends of a continuum. Focused, limited and formal interviews are frequently linked synonymously with structured interviews whereas unfocused, in-depth and informal interviews are associated with unstructured interviews. In reality, not all research interviews can be tidily allocated into either one of the two ends as they lie somewhere along the continuum.

Powney & Watts (1987) categorised interviews into respondent interviews and informant interivews . In respondent interviews, the interviewer was the locus of control, overtly directing the proceedings throughout the interviewing process. The role of the interviewee was to provide responses to the questions asked by the interviewer. According to Powney and Watts, the most important issue in all respondent interviews is the interviewer's issues. This is in contrast with the informant interviews where the interviewee imposes his or her own structure on the interview session. Informant interviews are therefore unstructured from the interviewer's point of view. A respondent interview can be a tightly structured interview or a loosely structured one as long as the interviewer is in control. Tightly structured interviews which normally ask the same set of pre-established questions in the same order, probably fit more easily into a predominantly quantitative rather than a qualitative study. Unstructured interviews are widely used for data gathering in qualitative research. They offer the advantages of informal friendly conversations (Seidman, 1991), providing opportunity for free-flowing and unconstrained conversations (Goodwin & Goodwin, 1996). However, as noted by Fetterman (1989), conducting unstructured interviews ethically and productively could be difficult. Gorg and Ball (1983) considered semi-structured interviews as most suitable for interview studies in education as such type of interviews can provide a desirable combination of objectivity and depth.

In this study, two groups of participants consisting of the teachers and the head teachers were interviewed. This study was planned with the aim of seeking answers to various research questions relating to the implementation of Malaysian Primary Science Curriculum. Semi-structured respondent interviews were considered appropriate. All interview agenda were constructed by the researcher who was also the interviewer. While the semi-structured interviews enabled the researcher to provide some answers to the research questions, these type of interviews allowed some flexibility for the interviewees to raise some personal issues which have not been in the researcher's agenda. In this way, the researcher was able to gain insight into those issues which have not been raised during the interviews. This is very much essential in a study aiming to understand the complexity of factors influencing classroom teaching practices. All interviews in the study were audio-taped.

Head teacher interviews

The purpose of interviewing the Head Teachers of the two schools was to discover the type of institutional support available to the science teachers. The interviews were held in the respective Head Teacher's office. As both Head Teachers were fluent in English, interviews with both of them were conducted in English. It was not the researcher's intention to provide them with the questions before the interviews. However, as one of them requested the questions, the researcher then decided to provide them with the list of questions a few days before the interviews. The questions covered the areas of success and problems in implementing the science curriculum, the extent and nature of school support for science, and their perceptions of science and science education. See Appendix D1 for the interview protocol.

Teacher interviews

Many researchers recognise the difficulties inherent in capturing teacher thinking. The constraint of direct assessment of teachers' practical theory has been identified as that of the implicit nature resulting in many teachers being not aware of their beliefs or having a very limited consciousness of the theory underlying their practices (Kagan, 1990; Parsons, Graham, & Honess, 1983). Even teachers who recognise that they have a practical theory which determines their work will often have problems trying to formulate and articulate it (Handal & Lauvas, 1987; Kagan). Teachers may simply be reluctant to espouse their beliefs publicly, especially if they are unpopular beliefs, and beliefs appear to be highly contextualised (Leinhardt, 1990). Therefore, researchers must access teachers' beliefs indirectly.

Various methods have been used to explore and identify teacher thinking. Amongst them are questionnaires (Gustafson & Rowell, 1995; Shynamsky, Yore, & Good, 1991; Weinstein, 1989), interview-about-instances (Hewson & Hewson, 1989; Hewson et al., 1995), concept maps (Morine-Dershimer, 1989), stimulated-recall interviews (Marland, 1986; Mitchell & Marland, 1989; Nespor, 1987), biography and autobiography (Pinar, 1988), repertory grid technique (Ben-Peretz, 1984; Corporaal, 1991; Olson, 1981; Parsons et al., 1983; Pope, Denicolo, & Bernardi, 1990; Lakin &Wellington, 1994), teachers' metaphors and images (Tobin, Kahle, & Fraser, 1990), teachers' narratives (Beattie, 1995; Briscoe, 1996), and phenomenography (Larson, 1986; Marton, 1981; Prosser, Trigwell, & Taylor, 1994).

Data collected using any single method only represents that portion of their ideas that they are ready and willing to share with us. Research on teacher thinking within a constructivist framework can be enhanced by the use of multimethod approaches to minimise those constraints. It has been argued that multimethod approaches not only allow access to the multifaceted nature of teaching and learning, thus leading to improved understanding of the complex and interrelated processes of personal experiences, beliefs and practices, but also allow triangulation of data from multiple sources (Fang, 1996; Kagan, 1990; Pope & Denicolo, 1993; Solas, 1992).

This study included four types of interview with each of the five teachers: (i) an interview-about-instances, (ii) a stimulated-recall interview, (iii) a curriculum interview, and (iv) an interview about science teaching and learning strategies. Each of these interviews lasted about 45 minutes to an hour. The interviews were conducted in a mixture of three languages, Bahasa Malaysia, Chinese and English, depending on the degree of fluency and preference of the teacher concerned. The interviews with the Chinese school teachers were conducted mainly in Chinese while the interviews with the Malay school teachers were in Bahasa Malaysia. The researcher was comfortable with the use of the three languages, having sufficient language proficiency and cultural sensitivity to conduct the interviews efficiently. In Sin Hwa Primary School, the researcher was given the use of the Deputy Head Teacher's office throughout the period of the study and all interviews were held in his office. The Deputy Head Teacher worked in the morning session and the researcher was working with teachers in the afternoon session. In St. Elizabeth Primary School, the interviews were held in either the science room or the school resource centre, depending on their availability at the time of the interview.

i. Interview-about-instances

The "interview-about-instances" technique was developed originally by Osborne and Gilbert (1980) to explore students' understanding of a particular concept by using familiar situations depicted on separate cards by means of a line drawing. This technique was used to gain insight into children's and adults views of the world. Hewson and Hewson (1989), and Hewson et al. (1995) used this technique as an experimental task to reveal science student teachers' and experienced science teacher's conceptions of teaching science respectively. The interview task was designed to enable respondents to consider the components of an appropriate conception of teaching science, at the same time providing an environment in which a variety of views could be expressed without bias from the task structure. It was developed to allow subjects to respond to particular events while encouraging them to link the events to larger conceptual issues.

In this study, ten instances were created to reflect a spectrum of possible science teaching activities in primary classrooms. Some of them were commonly used by Malaysian primary science teachers, while others which were espoused by the new curriculum were less commonly used. The content of the instances was drawn from the five fields specified in Year Four of the Malaysian Primary Science Curriculum. They are (i) the living world; (ii) the physical world; (iii) the material world; (iv) the technology world; and (v) the earth and the universe. Each instance was typed on a 12 cm by 4 cm card and was shown to the teacher. Two examples are given below:

a. Teacher explains breathing mechanism of various animals.
b. Pupils record the different phases of the moon over a period of one month.

For each instance, the researcher requested the teacher (i) to explain why the given instance was suitable or unsuitable for primary four pupils, (ii) to suggest other suitable activities, and (iii) to state her preference for the activity or activities that she would use in her lessons. Refer to Appendix D2 for the interview protocol and description of the ten instances.

ii. Stimulated-recall interview

Typical stimulated-recall interviews involve using records of task performance as stimuli such as audiotapes, videotapes, photographs and pictures. This stimulates recall of thoughts to enable the interviewee to provide retrospectively, self report data on his or her thought processes. This technique was originally developed by Bloom (1953 cited in Calderhead, 1981) to study the thought processes of university students in lectures and discussions. Since then, it has been used in process-tracing research to study the mental functioning of people at work in various task environments, including expert physicians, diagnosticians of children's reading problems, and counsellors (Calderhead, 1981). In classroom-based research, the stimulated-recall interviews were used to investigate the thought processes of students during learning (Marland & Edwards, 1986), and those of teachers while teaching (Clark & Peterson, 1986). Stimulated-recall interviews have taken slightly different forms in different research contexts with regard to deciding who is in control: the researcher, the teachers or shared control. In some studies, teachers viewed the entire videotape while in others, only portions of the tape were viewed.

In this study, the interview was supposed to begin with the teacher taking control of the video playback and stopping the video tape at any point he or she thought was significant or needing of comment. This was to be followed by viewing the researcher-selected segments of the recording and the teacher would then respond to questions initiated by the researcher. Due to unforeseen circumstances, the researcher was unable to carry out the stimulated-recall interviews as planned in both the schools. For St. Elizabeth School, the video cassette recorder was not in working condition for the entire period of the study while the two teachers in Sin Hwa School expressed their concerns about seeing themselves in action during the interviews. Instead, each of the teachers was given the duplicate copy of the videotape of her lessons to be viewed by the individual teacher before the stimulated-recall interview. All the stimulated-recall interviews were conducted as soon as possible after the teacher has taught the required lessons so that the memory was still fresh. Two of the teachers indicated that they had seen parts of the videotape of their lessons while the other three teachers admitted that they had not found time to view the tapes before the interview.

Before the stimulated-recall interview, the researcher viewed the videotapes of all lessons taught by the teacher and selected sections of the videotapes for discussion and clarification with the teacher during the interview. The actual interview started with the researcher giving an overview of all lessons taught followed by a more detailed analysis of each lesson. This was used to trigger teachers' recall of decision making that occurred during teaching. All teachers seemed to have vivid memory of the lessons observed as they were able to recall various instances of the lessons easily. Questions asked during the stimulated-recall interviews were different for each teacher. The following are some examples of the questions asked during the interview with one of the teachers:

1. What are the main ideas that you were trying to teach in the first session?
2. Did you try to relate their [pupils'] answers to that of yours?
3. In your second session, you explained about the life cycles of butterflies, bees, frogs and chickens. Is that too much?
4. Do you think it is required by the syllabus?
5. You used about twenty minutes to let the pupils to make charts of animals which give birth. What was your purpose?
6. What was the purpose of showing your pupils the video and the slides?

iii. Curriculum interview

Semi-structured questions were asked in this interviews to investigate (i) the teachers' understanding of the requirements of the curriculum, and (ii) the teachers' views of the curriculum. Loosely structured questions to explore the school support provided to these teachers were also included in this interview. Refer to Appendix D3 for the interview protocol.

iv. Interview about science teaching-learning strategies

Initially, the researcher explored the possible use of Repertory Grid Technique in investigating teachers' conceptions of the various science teaching-learning strategies. Much effort and time was spent on reading up literature on the technique, and networking with relevant authors on procedure and data analysis involved in using this technique.

Repertory grid technique was developed originally by Kelly (1955) for his Personal Construct Theory. The central notion of this theory is that there is no objective truth in life and that each of us constructs our own versions of reality based on a personally organised system of interpretation or constructs of experienced events. Kelly developed the repertory grid as a way to explore personal construct systems, enabling the researcher to understand the way in which people interpret their experience.

Even though almost all of the early work on personal construct theory looked at the construct system of the psychotherapeutic client, later there has been a growing interest in the role of personal construct theory in research and practice in education (Solas, 1992). Various researchers have highlighted Kelly's Repertory Grid Technique as an appropriate technique in the study of teacher thinking from a variety of perspectives (Corporaal, 1991; Lakin & Wellington, 1994; Mumby, 1982, 1984; Olson, 1980; Parsons et al., 1983; Pope et al,, 1990).

A standard grid with researcher-generated elements and constructs was to be supplied for the teacher to be completed. As the purpose here was to explore how teachers viewed different primary science teaching techniques, the elements and constructs included a range of science teaching events that the researcher assumed the group of teachers could construe. Thus, these elements and constructs were representatives of the area to be investigated (Beail, 1985; Fransella & Bannister, 1977; Pope & Denicolo, 1993). Supplied elements and constructs which were not familiar to the teachers would be discarded. Teachers were also encouraged to add on to the elements those science teaching events which they have often used but have not been supplied. What was important is that the supplied elements or constructs should be meaningful to the teachers. The concreteness and homogeneity of elements were maintained to help the teacher to overcome some of the problems faced in comparing and contrasting elements (Pope & Denicolo).

The pilot study done with a New Zealand secondary science teacher did not indicate any major problems in using the Repertory Grid Technique. However major problems became apparent when trying to use this technique with the teachers in the sample. The teachers' so called 'familiarity' with most of the science teaching-learning strategies was restricted to having heard of the strategies rather than having personal experiences with these strategies. It was obvious from their responses that besides teacher explanation which they frequently used, they have neither experienced nor used most of the other strategies. Even if they have used it, it was very infrequent. In their own words, it was "last year or many years ago". The researcher decided to abandon the original idea of the use of Repertory Grid Technique.

Instead, the teacher was shown a list of science teaching-learning strategies and was requested to talk about each of the strategies, relating as much as possible to her personal experiences. These strategies included pupil experiments, teacher demonstrations, visits, projects, teacher explanation, role plays, simulations, invited speakers, games, drama, group discussion and the use of visual and audio-visual resources. The teacher could choose not to talk about those teaching-learning strategies which were not familiar to her. All the five teachers revealed that they were not familiar with role plays and simulations and therefore they did not talk about these two instructional strategies. However, they agreed to talk on 'drama' or 'acting' when these terms were suggested as alternatives to 'role plays' and 'simulations'.

4.6.3 Documents

Document collection and analysis is a detached, neutral, unobtrusive and non-interactive strategy requiring little or no reciprocity between the researcher and the participant (McMillan & Schumacher, 1997). Learning about an organisation, its structure and how it functions may not immediately be visible in observations or interviews, but can be done by studying its reports, correspondence and memos (Strauss & Corbin, 1990). Strauss and Corbin suggested that information about the behaviours, experiences, beliefs, knowledge, values and perceptions of the subjects whose materials they study can be used to describe and understand more fully the culture, institution, or other focus of the qualitative research. Bryman (1989, p.150) identified three main functions of the source of data obtained by document collection and analysis as the capability to:

i. provide information on issues that cannot be readily addressed through other methods;
ii. check the validity of information deriving from other methods; and
iii. contribute a different level of analysis from other methods.

In this study, the documents collected are categorised into three groups (i) school documents (ii) science curriculum documents and (iii) science teaching-learning related materials. These documents are listed in Table 4.4. The documents provided supplementary data to those obtained from interviews and observations.

Table 4.4: Documents Used in the Study

Categories	Document descriptions
Science curriculum documents	Syllabus guide Pupils' textbook Teachers' guidebook Pupils' workbook School-adopted reference book 12 modules (PULSAR)
School documents	Minutes of staff meetings Minutes of curriculum meetings Minutes of science meetings School calendar
Science-related teaching-learning documents	Teachers' record books Test / exam papers Pupils' exercise books Worksheets

4.7 Research Procedure

This section describes the various events involved in the research process with specific focus on the data collection phase. Table 4.5 contains a summary of these events arranged in chronological order.

Pilot study: November 1996

After the various interview protocols were developed, a pilot study was carried out with the aim of improving them and to provide the researcher with an insight into possible problems which might arise during these interviews. The interview-about-instances was carried out with a Malaysian teacher training college lecturer who was undertaking graduate study in New Zealand at the time of the study. The science teaching-learning strategies interview was piloted with a New Zealand secondary school science teacher. Both interviews were audiotaped and transcribed in full. The findings of the pilot study were discussed with the supervisors. The importance of exploring participants' perceptions and avoiding leading questions was highlighted.

Getting approval from EPRD: 31 December 1996

The researcher sent in the letter to the director of the EPRD at the Malaysian Ministry of Education to ask for permission to carry out the research in Malaysia (Appendix E1). Permission was granted on 20 January, 1997 (Appendix E2).

Selecting the schools: 7 March 1997

Data on the past three years UPSR performance of all schools in the town where the study was to take place, was provided by the Sabah State Education Department. This was used in the selection of the two schools for the study. Initially three SRKs and two SRJK(C)s were shortlisted in the order of their performances in UPSR over the last three years. This was necessary as some of the schools might not have experienced teachers teaching science or there was also the probability that some of these schools might not be willing to participate.

A plan was drawn up to visit all the five schools within the following two days. The visit to two national schools on the first day ended with disappointment. In one school, according to the Head Teacher, all the science teachers were inexperienced teachers, having less than three years of teaching experience. In the second school, one of the experienced science teacher just got a promotion and would be leaving the school the following month on transfer to another school. Another science teacher who would fit into the researcher's category did not want to be involved in the study as he would be sitting for his final year extra-mural degree course in a month's time. A visit to the last national school on the list, came with a positive response where almost all the science teachers were experienced teachers. The researcher could have chosen either of the two SRJK(C)s as both schools had experienced teachers. However, as the head teacher in one of the two schools was due to retire in about a month's time, the researcher decided not to include that school. The classes observed in the two selected schools were taught in different sessions, in the morning for one school and in the afternoon for the other school. This provided the researcher flexibility to adjust the field work schedule in between the two schools.

Getting permission from the State Education Department: 12 March 1997

After obtaining verbal consent from the Head Teachers of the two schools, the researcher wrote to the Director of Sabah State Education Department to request for permission to do the study in the two schools (Appendix E3). The researcher delivered the letters to the Director of Sabah State Education Department personally, and the permission was granted on the same day.

First two days in school: 13 March 1997

With the approval letters from the director of the EPRD and director of the Sabah State Education Department, the researcher had the official permission to gain access to the schools to begin the data collection for the study. In each school, it began with an official meeting with the respective head teacher when the researcher explained the purpose of the research and the involvement of the head teacher and the teachers in the study as contained in the head teacher information sheet (Appendix F1). When all queries had been answered, and upon agreement on the conditions stated in the head teacher consent form (Appendix G1), the head teacher signed the consent form and returned it to the researcher. An appointment was made with the head teacher for the interview. The head teacher was given the questionnaire (Appendix H1) which was to be completed and returned to the researcher at the time of the interview. The meeting ended with the researcher requesting the head teacher to nominate two experienced and reasonably good teachers teaching primary four science to take part in the study. Mr. Ong, the Headmaster of Sin Hwa Primary School seemed to have no second thoughts about who the two teachers were. Mrs. Lim and Mrs. Chan were introduced to the researcher and he encouraged them to provide full co-operation. Pn. Doris, the Headmistress of St. Elizabeth Primary School introduced the researcher to Pn. Jane, the Head of Science Department in the school to decide on the teachers to be involved in the study. The three teachers who were teaching primary four science during the time of the study were Pn. Jane, Pn. Fatimah and Pn. Christina. All three teachers agreed to take part in the study.

The researcher's initial intention was to meet all the participating teachers from the same school together to explain to them the purpose of the study and their involvement. However, as it was difficult to arrange a common time to meet all of them, the researcher had to arrange for separate meetings with each of the teachers. During the meetings, each of the teacher was explained the information as contained in the teacher information sheet (Appendix F2). After the teacher had signed the consent form (Appendix G2), the researcher discussed with the teacher the schedule of the interviews and on the lessons to be observed. The teachers were given the questionnaire (Appendix H2) which was to be completed and returned to the researcher during their first interview.

During this preliminary phase, the researcher also trialled the use of the newly acquired video camera in one class.

Data collection: 17.3.97 - 16.5.97

From the second week of March to the end of April, the researcher visited the schools almost every day. The researcher conducted four interviews with each of the five teachers and observed their science lessons on 'Animal Reproduction'. All interviews were audiotaped and lessons videotaped. The Head Teachers of both schools were interviewed to establish some sense of the science context in the school as a whole and more specifically to find out the institutional support provided to the science teachers. Documents such as minutes of meetings and school calendars were obtained from the Deputy Head Teachers of the schools. Other documents and printed materials such as teachers' record books, timetables, pupils textbooks and exercise books, science test and examination papers, and science worksheets were obtained from the respective teachers. These materials were scrutinised and the relevant ones were photocopied for future reference.

Leaving school: 16.5.97

A small gift was presented to each of the participants in the two schools in appreciation of their co-operation throughout the study. The researcher received a bouquet of roses from the three teachers of St. Elizabeth School, which was a pleasant surprise.

Feedback of report findings of the participants: June, 1998

Upon completion of writing the report on the findings of each of the participants, a summary was sent to each individual concerned, requesting their feedback on the accuracy of the report and for rectification of findings that were regarded as misconstrued.

Table 4.5: A Summary of the Events Involved in the Research Process

Phases of Research Process	Dates	Events
Research proposal	January 1996 to November 1996	Formulating research problem and research questions Reviewing the literature Designing research methodology Writing research proposal
Pilot study	1996 November	Piloting interviews: i. Repertory Grid technique ii. Interview-about-instances
Preparation for field work	1996 December	Request for permission from EPRD Request for permission from Massey University Ethical Committee
Data collection	3.3.97 - 7.3.97	Searching for two high performance primary school
	12.3.97	Request for permission from the state education department to undertake the study in the two schools.
	13.3.97	Meeting the three teachers of St. Elizabeth Primary School
	13.3.97	Meeting the two teachers of Sin Hwa Primary School
	14.3.97	Trial videotaping of one of the teachers
	17.3.97	Videotaping of Mrs. Lim's lessons (1&2)
	18.3.97	Videotaping of Mrs. Lim's lessons (3&4)
	19.3.97	Interview with Mr. Ong
	21.3.97	Videotaping of Mrs. Lim's lessons (5&6)
	24.3.97	Videotaping of Mrs. Chan's lessons (1)
	25.3.97	Interview I with Pn. Fatimah
	26.3.97	Videotaping of Mrs. Chan's lessons (2&3)
	27.3.97	Videotaping of Mrs. Chan's lesson (4&5)
	31.3.97	Interview II with Pn. Fatimah
	2.4.97	Videotaping of Pn. Fatimah's lessons (1&2)
	3.4.97	Interview I with Mrs. Chan
	3.4.97	Interview I with Mrs. Lim
	4.4.97	Videotaping of Pn. Fatimah's lessons (3,4&5)
	7.4.97	Interview III with Pn. Fatimah

(Continued)

Table 4.5: A Summary of the Events Involved in the Research Process (Continued from p. 95)

Phases of Research Process	Dates	Events
	8.4.97	Videotaping of Pn. Jane's lessons (1,2&3)
	9.4.97	Videotaping of Pn. Christina's lessons (1&2)
	10.4.97	Videotaping of Pn. Jane's lessons (4&5)
	10.4.97	Interview II with Mrs. Chan
	10.4.97	Interview II with Mrs. Lim
	11.4.97	Interview I with Pn. Christina
	11.4.97	Videotaping of Pn. Fatimah's lessons (6,7&8)
	14.4.97	Videotaping of Pn. Christina's lessons (3,4&5)
	16.4.97	Interview I with Pn. Jane
	16.4.97	Videotaping of Pn. Christina's lessons (6&7)
	16.4.97	Videotaping of Pn. Fatimah's lessons (extra)
	17.4.97	Interview III with Mrs. Chan
	17.4.97	Interview III with Mrs. Lim
	21.4.97	Videotaping of Pn. Christina lesson (extra)
	21.4.97	Interview IV with Pn. Fatimah
	24.4.97	Interview II with Pn. Christina
	24.4.97	Interview IV with Mrs. Chan
	24.4.97	Interview IV with Mrs. Lim
	28.4.97	Interview II with Pn. Jane
	2.5.97	Interview III with Pn. Christina
	2.5.97	Interview III with Pn. Jane
	5.5.97	Interview IV with Pn. Jane
	6.5.97	Interview with Pn. Doris
	7.5.97	Interview IV with Pn. Christina
Data analysis	June 1997 to June 1998	Transcribing data Coding and categorising data Interpreting data Writing up case study reports Sending reports to participants for feedback
Data presentation	1998 January to May 1999	Drafting the thesis Revision of the thesis

4.8 Data Analysis

Informal analysis of data began immediately after the first data collection. After each lesson observed, the researcher viewed the videotape of the lessons at least three times to note down what the teachers and the pupils did. During the stimulated-recall interviews, teachers were asked to clarify why they conducted their lessons the way they did. Similarly, each audiotape of the interviews was listened to at least twice to identify any matter which was unclear. Relevant questions were structured to seek clarification in the following interview session. This was necessary as it was not convenient for the researcher to communicate with the participants after the three months of field work as the researcher would have returned to New Zealand.

Formal data analysis took place upon completion of the data collection process. All interview audiotapes were directly translated and transcribed in full into English. For the case of the lesson videotapes, the video camera was focused on the teacher. Therefore, it was able to record practically all verbal and non-verbal events between the teacher and the pupils while the teacher was teaching in a whole class mode. However, it was unable to do so when the pupils were working in their groups. As such, the videotape transcripts only consist of events recorded by the camera. However, the researcher took written notes on events which were not recorded by the camera but were considered significant.

Examples of transcripts of the four types of interviews with one of the teachers are included as Appendices I1 - I4. Lesson transcripts for the same teacher are included as Appendices I5 - I7. An example of a head teacher's interview transcript appears as Appendix I8. All transcripts and documents were coded for ease of reference. The code for the teachers' transcripts consists of four parts. The first part of the code is a number allocated to each school, and the second part is to identify the teacher in the school. The third part is a number allocated to each interview or lesson transcript, while the last part of the code refers to the page number of the transcript.

Sin Hwa Primary School:	S1	St. Elizabeth School:	S2
Mrs. Chan:	S1:T1	Pn. Jane:	S2:T1
Mrs. Lim:	S1:T2	Pn. Christina:	S2:T2
		Pn. Fatimah:	S2:T3
Science teaching-learning strategies interview	I1	Lesson observation session I	O1
Curriculum interview	I2	Lesson observation session II	O2
Interview-about-instances	I3	Lesson observation session III	O3
Stimulated-recall interview	I4	Lesson observation session IV	O4

For examples, S1:T2:I3:P6 refers to page six of Mrs. Chan's interview-about-instances, and S2:T3:O2:P4 refers to page four of Pn. Fatimah's second observation session. The code for the head teachers' interview transcripts consists of three parts. As with the teachers' transcripts, the first part is the number allocated to the school; the second part HT indicates the head teacher; and the third part refers to the page number of the transcript. Thus, S1:HT:P3 refers to page three of the interview with the Head Teacher of Sin Hwa School. The school documents are more simply coded with two parts. For examples, S1:D1; S1:D2 and S1:D3 refer to documents one, two and three of Sin Hwa School, while S2:D1, S2:D2 and S2:D3 refer to documents one, two and three of St. Elizabeth School.

As the study involved five teachers, data analysis consisted of two stages: the within-case analysis and the cross-case analysis (Merriam, 1998). Data analysis began the within-case study, where each case was treated as a comprehensive case in and of itself. It began with scanning through all of the data for each teacher. This was to enable the researcher to learn as much about the contextual variables as possible that might have a bearing on the case. Both observation and interview data were scanned over and over again in order to identify the underlying themes in the data and the data were sorted into tentative gross categories. The "finding patterns and developing category systems" approach (Patton, 1990) was used. The construction of these categories was guided by the research questions and influenced by literature review on various theories for science teaching such as the teachers' perceptions of the nature of scientific knowledge, instructional strategies and pupils' learning, their understanding of the science curriculum, and their problems in implementing the curriculum. The researcher "worked back and forth between the data and the classification system to verify the meaningfulness and accuracy of the categories and the placement of data in categories" (Patton, p.403). Themes and categories derived from the head teachers' interviews, field notes and documents, were compared and corroborated with the data collected from classroom observations and teachers' interviews. Emerging themes for the teachers varied and tentative categories were constructed for each teacher.

The first round of analysis was followed by returning to the transcripts for further comparison and refinement of categories, and identification of additional categories. Each incident was compared and contrasted with other incidents across transcripts, thereby generating hypotheses that were interconnected and constantly refined by information emerging from the data (Westerman, 1991). This cyclic pattern of category construction and transcript coding continued through several phases of analysis and led, eventually to the reduction of categories and the generation of theoretical prepositions. As far as possible, teachers' own words were used to tell the story of their experiences, opinions, feelings, and knowledge relating to science teaching. Excerpts extracted from the documents were used to support teachers' lessons and interviews data.

Upon completion of the analysis of data from the five teachers, a copy of the report findings for each of the case study teachers and their head teachers was sent to each individual concerned for comments and reactions. Appendix J is a copy of the letter sent to the research participants requesting feedback on report findings. This was to enable the research participants to check for accuracy of data and validate the findings of the report. Lather (1986) considered this procedure a critical component for establishing the validity and trustworthiness of the study's findings by reducing the bias inherent in the interpretative process. Lather contended that statements or events contained in the report seen by the participants as either inaccurate or threatening to confidentiality should be rectified or eliminated where appropriate. In this study, the two Head Teachers and the three teachers from St. Elizabeth School, made some comments about the reports and adjustments were made to the final report. However, the two teachers from Sin Hwa School had not stated any disagreements with the case study reports. They described the reports as fairly accurate of what they said and did during the study.

Once the analysis of all cases was complete, cross-case analysis began which sought to find generalisations across case. Constant comparative method and grounded theory developed by Glaser and Strauss (1967) were used. Constant comparative method was used to identify patterns and relationships among the five teachers across the two schools. The grounded theory approach was adopted for the present study. This was because even though various studies had investigated the factors affecting curriculum implementation, such studies were mainly confined to Western classrooms. As such, theories or hypotheses from these studies might not be relevant to the Malaysian contexts. The 'grounded theory' is so called because the abstractions are built from observations (McMillan & Schumacher, 1997), and are embedded in reality (Crowl, 1996) rather than deduced from prior theories. Glaser and Strauss emphasised the importance of theory building in social science research, rather than testing theories deduced from pre-existing theories. They contended that social science research should discover theories which are 'grounded' in the data during the research process. This study adopted the theory-building mode in which the researcher learnt about the teachers' conceptions from their perspectives by starting with an open mind. There was no prior determination of categories into which to classify the data. Rather these were formulated through repeated reading and sorting of data from the various sources. Categories were repeatedly re-examined and redefined until a sense of meaning stabilisation (Aguirre et al., 1990) was established.

4.9 Ethical issues

This study was carried out in accordance with (i) the standard procedure for seeking permission to do research in Malaysian schools and any other divisions which come under the jurisdiction of Malaysian Ministry of Education, and (ii) the ethical guidelines and procedures outlined by Massey University Human Research Ethics Committee (Massey University, 1994).

The standard procedure for seeking permission to do any study under Malaysian Ministry of Education is a top-down model, starting from obtaining permission from the Director of EPRD at the Malaysian Ministry of Education, then the Director of the Sabah State Education Department, followed by the head teachers, and finally the participating teachers.

The study was also carried out in line with the Code of Ethical Conduct for Research and Teaching Involving Human Subjects. Even though the study focused on teachers, interviews also included head teachers. Information sheets and consent forms for these groups of participants were prepared using Ethics Committee guidelines. Information sheets contained information on the nature and objectives of the research, the role of the participants, the way the data was to be collected, and the amount of time the participants would be required. Ethical considerations such as form of access, privacy, confidentiality and maintenance of anonymity for the research participants were also included. Pseudonyms were used for names of the participating schools, head teachers, and teachers. The consent forms informed the participants of their role in the research process and their right to withdraw from the study at any time and to decline to answer any particular questions. All participants signed the consent forms upon agreeing to all the conditions set out in the information sheets and the consent forms. All videotapes, audiotapes and their transcripts were stored in locked cupboards and their access was limited to only the researcher and the thesis supervisory committee.

4.10 Triangulation, Validity, Authenticity and Reliability

According to Mathison (1988), the image of data converging upon a single proposition about a social phenomenon is a phantom image. Thus the chief advantage of the multimethod approach lies in the data's diversity and the opportunities for comparison that this diversity affords (Brewer & Hunter, 1989). Smith and Kleine (1986, cited in Mathison) made the same point when they suggested that the use of multimethods resulted in different images of understanding thus increasing the potency of evaluation findings. Whether the data converge, are inconsistent, or are contradictory, the value of triangulation lies in providing evidence such that the researcher can construct explanations of the social phenomena from which they arise. The different methods used in this study are able to provide a rich source of information on teachers' personal understandings of science teaching and learning, their perceptions of the problems, and how these perceptions influenced their classroom practice. All these bear direct influence on their ability to implement the new science curriculum.

McMillan and Schumacher (1997) defined the validity of qualitative designs as the degree to which the interpretations and concepts have mutual meanings between the participants and the researcher. The strategies used to enhance validity in this study are summarised in Table 4.6. Multiple researchers and long-term observation (McMillan & Suchumacher; Merriam, 1998) were not included in the study due to the constraints of resources and time faced by the researcher.

Table 4.6: Strategies to Enhance Research Validity

Strategies	Descriptions
1. Triangulation	Multiple data sources
2. Participant language; verbatim accounts	Literal statements of participants and quotations from documents were used.
3. Low-inference descriptors	All audiotapes and videotapes were transcribed in full.
4. Mechanically recorded data	All interviews were audiotaped and all lesson observed were videotaped
5. Participant review	Case study reports were sent to the head teachers and the participating teachers for confirmation of accuracy of representation. Any misrepresented data was rectified.

According to Merriam (1998), internal validity hinges on the meaning of reality involving questions like "How congruent are the findings with reality?", "Do the findings capture what is really there?", and "Are investigators observing or measuring what they think they are measuring?" (p.201). Stenhouse (1982) also raised the issue of the importance of the conception of reality in case study reports. This implies that the validity of the methods used in this study depends primarily on the authenticity of the data provided by the teachers. As the study purported to probe teachers' understanding and knowledge concerning science, science teaching and learning, and science curriculum, various measures were taken at various stages of data collection to motivate the teachers to provide accurate and authentic accounts of their thinking in these areas. At the beginning of all interviews, the researcher reminded the participants that the researcher's intention was not to evaluate their teaching. Rather, the researcher was interested in listening to their views about their teaching.

The researcher gained the confidence of the teachers by being open and frank about the purposes of the research, and by assuring them of anonymity and confidentiality. Throughout the interviews, the researcher closely followed the common guidelines on interviewing techniques which are aimed at establishing rapport between the teachers and researchers, reducing the problems of anxiety, confidence levels and distraction. A relaxed, friendly, supportive and informal setting for the interview was created so that the research was not perceived as a threat. Leading questions were avoided as far as possible and the teachers were encouraged to initiate self-reporting as much as possible. Listening attentively to the teachers, showing interest in their responses, and requesting clarification or confirmation, were used to make them feel that their responses were being taken seriously, thus providing encouragement and invitation for further disclosure. Evaluative comments, especially negative ones, were avoided as these might discourage the teachers from further disclosure of their thoughts. However, there were occasions when the researcher offered advice to the participants. For example, the researcher suggested possible activities which could be carried out in the science lessons after the teacher had related her approach to teaching a particular concept. This happened occasionally when it became clear that the teachers seemed to expect such advice.

The traditional meaning of reliability refers to the extent to which research findings can be replicated. It is based on the assumption that there is a single reality and that the study will yield the same results if it is repeated. Merriam (1998) considered reliability as problematic in the social science due to the non-static nature of human behaviour. Merriam was of the opinion that achieving reliability in the traditional sense as "not only fanciful but impossible" (p.206). She therefore described the term reliability to be something of a misfit when applied to qualitative research. The terms 'dependability' or 'consistency' are considered more appropriate (Lincoln & Guba, 1985; Merriam, 1998). An audit trail (Merriam, 1998) has been incorporated into this study to improve 'consistency' of the research findings. This was done by explaining in detail the research procedure so that the readers can authenticate the findings of the study (Guba & Lincoln, 1981).

4.11 Summary

A case study approach was considered appropriate to understand the factors which influenced the teachers' science classroom practices in the context of implementing a new curriculum. Five experienced teachers from two schools were selected as the researcher believed that these cases studied in depth would yield many insights about why these teachers practised what they did.

In this study, interviewing, observing, and examining documents merged in the process of understanding and describing the case teachers' science classroom practices. The primary sources of data were obtained from the researcher's observations of the teachers' science lessons and the teachers' interviews. Head teachers' interviews, and various school and science-related documents and materials provided secondary but important sources of data.

The use of a multimethod approach to data collection not only allows for a holistic interpretation of the phenomenon being investigated but also enables the researcher to validate and cross-check findings. Strategies such as the use of participants' own words, low-inference descriptors, mechanically recorded data, and participant review were incorporated into the study to enhance validity of the research design. Various measures were taken to motivate the participants to provide accurate and authentic accounts of their thinking. These included establishing a good rapport between the participants and the researcher, avoiding leading questions and evaluative comments especially negative ones, and showing interest in their responses. The study was carried out in accordance with (i) the standard procedure for seeking permission to do any study under Malaysian Ministry of Education, and (ii) the Code of Ethical Conduct for Research and Teaching Involving Human Subjects. Ethics considerations such as participants' consent, privacy, confidentiality and maintenance of anonymity for the research participants were accounted for.

CHAPTER FIVE

CASE STUDY REPORTS (PART I)

Chapter Five and Chapter Six provide an in-depth examination of how five experienced teachers from two schools implemented the inquiry-based Malaysian Primary Science Curriculum in their classrooms, together with the contextual factors and personal factors which influenced their classroom practice. Chapter Five reports the findings of the two teachers from Sin Hwa Chinese Primary School while the findings of the three teachers from St. Elizabeth National School are reported in Chapter Six. Each chapter begins with a description of the respective school including the school's ethos and culture, the role of the head teacher and the science head. This is followed by a description of each teacher's profile, her classroom practice, and her knowledge and understanding of science and science teaching under various emerging themes.

5.1 Sin Hwa Chinese Primary School

Sin Hwa Chinese Primary School, established in 1917, is a national type vernacular school where all subjects are taught in Chinese with the exception of English and Bahasa Malaysia. At the time of the study, the school had an enrolment of 2,467 pupils with 1,195 girls and 1,272 boys, the majority of whom were Chinese with only 408 non-Chinese pupils. The teaching staff comprised of 71 female and 8 male teachers, six of whom were untrained while the rest were trained. All teachers were Chinese, except the Islamic religious class teacher who was a Malay. There were eight classes for each standard, starting from primary one to primary six with a total of 48 classes. For each standard, the pupils were streamed into two 'good' classes, two 'weak' classes and four 'average' classes based on their performance in Mathematics, Chinese, Bahasa Malaysia and English. The good and average classes had about 50 pupils while the weak classes had around 40 pupils. Most urban schools in the country have a high pupil enrolment, thus having to conduct classes in two sessions to accommodate all the pupils. For Sin Hwa School, Primary One, Primary Two, Primary Five and Primary Six classes were in the morning session which began at 7.05 a.m. and finished at 12.25 p.m.. Primary Three and Primary Four classes were in the afternoon session starting at 12.25 p.m. and finishing at 5.45 p.m.. Both sessions had 10 thirty-minute lessons each day with a 20-minute break in the middle of the school day. Pupils gathered for assembly in the school hall every Monday before lessons began. The last three periods of Friday were allocated for co-curricular activities. Co-curricular activities were divided three groups: (i) 'uniform' organisations, e.g. St. John Ambulance and Red Crescent Society, (ii) clubs and societies, e.g. English Society, Debating Society and Science Club, and (iii) games. All pupils were required to participate in two activities from any two groups. Table 5.1 shows the timetable of Primary 4C in the school.

Table 5.1: Sin Hwa School Primary 4C Timetable

	Monday	Tuesday	Wednesday	Thursday	Friday
11.45-12.25	Assembly				
12.25-12.55	Bahasa Malaysia	Moral Edu / Islam	Chinese	Moral Edu / Islam	Chinese
12.55-1.25	English	Moral Edu / Islam	Chinese	Moral Edu / Islam	Chinese
1.25-1.55	Chinese	Maths	Chinese	Chinese	Local Studies
1.55-2.25	Chinese	Maths	Bahasa Malaysia	Chinese	Music
2.25-2.55	Chinese	Bahasa Malaysia	Bahasa Malaysia	Physical Education	Moral Edu / Islam
Break					
3.15-3.45	Maths	English	Local Studies	English	Science
3.45-4.15	Science	Science	Maths	Living Skills	Bahasa Malaysia
4.15-4.45	Science	Science	Maths	Living Skills	Co-Curriculum
4.45-5.15	Local Studies	Music	Art	Maths	Co-Curriculum
5.15-5.45	Local Studies	Physical Education	Art	Maths	Co-Curriculum

The school had a school office, a staff room, 33 classrooms, a resource centre, a computer room, a hall and three specialist subject rooms. The specialist subject rooms included a science room, a living skills room resembling a wood workshop, and a room for Islamic religious lessons. Except for the Head Teacher and the Deputy Head Teacher who had their own offices, the rest of the academic staff were accommodated in the staff room. This is the norm of all schools throughout the country. The staff room was air-conditioned, a facility enjoyed by teachers of very few schools throughout the country. Each teacher's work space in the staff room consisted of a table and a chair, and with 79 teachers, there was little space to walk in between these tables.

The back wall of each classroom was fitted with a bulletin board which was divided into various sections for display of pupils' work in the various subjects. The front wall had a chalkboard in the middle with bulletin boards on both sides. A sliding magnetic board was built into the chalkboard to facilitate the display of charts and similar materials.

The resource centre had a library, an audio-visual room and a teaching aids room. The library was well-stocked with books in Chinese, Bahasa Malaysia and English. The library lending records and casual conversation with the clerical staff in charge of the library, revealed that story books seemed to be popular with pupils. Pupils seldom borrowed encyclopaedias and books with factual information. Very few teachers made use of the books in the library. The audio-visual room, with a seating capacity of about 200 people, had modern facilities like air-conditioning, a television, a video cassette recorder and a slide projector. Video cassettes available were those of school concerts and prize giving ceremonies. There were no video cassettes and slides related to the various school subjects. At the time of the study, the teaching aids room had yet to be organised, with charts lying on the floor. According to one of the participating teachers, the teaching aids which were previously kept in the resource centre were moved to a new room since the beginning of the school year.

At the time of the study, the science room was not ready for use with the equipment and materials supplied by the state education department still packed in boxes. The State Education Department had supplied these equipment and materials the previous year. According to the Head Teacher, the delay in organising the science room was due to the shortage of rooms and teachers' unfamiliarity with the terminology of the equipment. This had resulted in teachers not being able to use the relevant equipment and materials in their science lessons.

> R: At the moment, is the science lab functional yet?
>
> Mr. Ong: Not yet. We are in the process of doing that. We are in the process of arranging the science room.
>
> R: Has the department supplied you with some equipment?
>
> Mr. Ong: Yes. The department supplied us some science equipment last year. There is shortage of storage space and classrooms. We have no place to keep them. We just keep them inside the store room.
>
> R: Do the teachers use them [the equipment]?
>
> Mr. Ong: No. I am sorry to say that. The science equipment have not been used. The problem is with the terminology, the naming of the equipment which the teachers do not know. We are still waiting for some kind of briefing from the Education Department. If there is no briefing, we will have to find ways and means of translating from Bahasa Malaysia to Chinese. Teachers teaching in Chinese schools are not familiar with the terminology.
>
> (S1:HT:P1)

The school's ethos was one which strove towards academic excellence as well as recognising the more general educational benefits gained from pupils' participation in extra-curricular activities. Photographs of pupils who scored distinctions in all subjects for the previous year's UPSR were displayed on the bulletin board in front of the school office. Minutes of the staff meeting (S1:D1) revealed that extra tuition classes were arranged for all pupils in the school since the beginning of the school year. The frequency of these classes varied, with Primary Six pupils having to attend tuition classes every afternoon of the school days. Primary Five pupils attended these classes four afternoons a week while pupils of Primary One to Primary Four attended English tuition classes every Saturday morning. These classes were for UPSR subjects. They were conducted by the teachers in the school who were paid to run these classes outside school hours. Part of the payment came from the fees collected from the pupils, while the school board contributed the rest. Typical of Chinese schools in Malaysia, Sin Hwa School is strongly supported by the Chinese community. Thus, besides the funding provided by the Ministry of Education, the local Chinese business community provides the school with substantial financial support. In return, the community has high expectations for the school to produce quality education and high achievement test scores.

A variety of activities were planned for the year and they were listed in the school calendar (S1:D2). These included a Mathematics quiz, a general knowledge quiz, a singing competition, an art competition, a living skills competition, composition writing competition, and speech competitions in Chinese, Bahasa Malaysia and English. Pupils were chosen to represent the school in similar activities held at district, state and national levels, and the results of these events were displayed on the school bulletin board. Judging from the number of prizes won by the pupils in these activities, the school could be proud of the performances of its pupils. However, no science-related activities of this nature were evident. Science, being a new subject even though an UPSR subject, seemed to have been given low priority in the school agenda. Only marks for tests and examinations in Bahasa Malaysia, Chinese, English and Mathematics were on display on the staff room notice board while marks for other subjects including that of Science were not displayed.

Moral values were very much emphasised in the school culture. As indicated in the school calendar, each school week was given the name of one moral value such as "politeness week", "bravery week", "co-operation week", "peace week", "humility week", "obedience week", and "honesty week". Whenever possible, the name of the week was matched with an event closely associated with the value. For examples, the national teachers' day was celebrated on 16th of May, and therefore the particular week was named "respect teachers week", and the week on which Malaysia National Independence Day (August 31) fell was referred to as the "loyalty week". At the weekly assembly, pupils were reminded of the moral value for the week, and were encouraged to practise it. One or more pupils would come up to the stage to relate their experiences with the moral value of the week.

The school had a highly structured form of administration. It had an assessment policy which included six tests and two examinations in an academic year. Details of dates, the topics to be assessed, and the teachers responsible for setting each of the test or examination papers were set in the scheme of work for the various subjects. Subject teachers were required to follow the scheme of work as laid down by the respective heads of the standard concerned. The roles of teachers with special responsibilities like the head teacher, the deputy head teacher, the curriculum co-ordinator, the co-curriculum co-ordinator, the resource centre co-ordinator, the class teachers, and the subject heads, were explicitly spelled out on the first page of the school calendar. The school staff meeting seemed rather formal and structured. As noted in the minutes of the staff meeting, the meeting was convened the week before the new academic year began. The meeting began with the Head Teacher's report followed by reports from the various teachers with special responsibilities as described above. Each of these teachers informed the staff what had happened in the past year and what would be done for the coming year. The minutes of the meeting did not record other teachers bringing forth any other issues. The school had only one formal staff meeting for the whole academic year. However, the researcher was told by the head teacher that there was a weekly brief and unminuted staff meeting every Thursday during the tea break where he would convey the relevant information that required the teachers' attention.

5.2 The Headmaster: Mr. Ong

Mr. Ong was a lower secondary teacher for 21 years, and had taught Mathematics, English, Art and Music. His first appointment as the Head Teacher of a primary school was in 1988. In 1990, he was transferred to the position of the Head Teacher of Sin Hwa School. Since becoming the Headmaster of Sin Hwa School, he had not been teaching and had devoted full time doing the administrative work. He was educated in Chinese and passed Chinese School Certificate which was equivalent to Cambridge 'O' level.

Mr. Ong expressed his preference for teachers with strong science background knowledge to teach science. However, he was also of the opinion that any teacher with the right attitude should be able to teach any primary school subject including science. To overcome the problem of getting appropriate teachers to replace any teachers leaving the school, he employed the concept of generalist teachers in his school. Therefore, the school did not have specialist teachers and all of them were generalist teachers teaching various subjects. Mr. Ong admitted that his teachers were simply assigned the subjects that they had to teach. In a casual conversation with one of the teachers in the school, the teacher related that the teachers in the school were not consulted or given the option of teaching their preferred subjects. However, they were asked to indicate one subject which they did not wish to teach. According to this teacher, no teachers had been allocated to teach the subject which they did not wish to teach.

R: How do you choose science teachers?

Mr. Ong: So far we do not have any problem. We just assign [the subjects] to them. If they are science students, it is better. Even though they are not science students, they still can manage it. After all, primary science is not that difficult. We prefer teachers who have studied science. It would be easier for them. But sometimes due to allocation of subject teachers, shortage of teachers, teachers come at different time, teachers leave at any odd time. To get the replacement, we might not be able to get a teacher to replace a teacher to teach science. We cannot get the right type of replacement. We have to get any type of teacher to teach science.

R: What is your opinion of a good science teacher?

Mr. Ong: This not only applies to science teacher but also to other subjects. A good teacher should try to improve themselves from time to time, and should not stop learning. They should enrich themselves. Science teachers should do a lot of reading, to keep up to date with recent development in science, to be knowledgeable, to have initiative. This is very important. Teachers must have the right attitude. Teachers must be dedicated.

(S1:HT:P2)

Mr. Ong stressed the importance of getting more reference books and charts for the teachers. He has purchased an enlarger which could enlarge a picture many times its size. This could help the teachers to make their own charts easily from the pictures found in books. He also talked enthusiastically about the computer room where sophisticated computers were available but short of appropriate software. He was planning to get appropriate multimedia software in Chinese.

R: What type of support or facilities the school management has been able to provide to the science teachers?

Mr. Ong: At the moment we cannot do much. We are buying now some encyclopaedias. We are short of resources like reference books and materials. It is difficult for teachers to do reference work. That is why they depend so much on school texts and reference books supplied by the book dealers. They have used these reference books for enrichment. They depend so much on these reference books, what do you call it - supporting text. As far as the resource centre is concerned, we do have some charts and some other teaching aids. However, it is not complete. They are not enough. They are inadequate. We still depend so much on teachers making their own teaching aids. It is even better rather than looking for teaching aids. But again making teaching aids is another problem. Teachers need a lot of equipment and room to produce their own teaching aids. They still do it. A lot of our teachers are doing it. It is quite time-consuming.

R: I understand that besides teaching, teachers nowadays have quite a lot of administrative work. Do you think that it is fair that teachers should be asked to prepare materials?

Mr. Ong: Actually it is good for them to produce their own materials. They can do it. To produce simple teaching aids - it is not a problem. I manage to buy the enlarger. Teachers use the enlarger to draw charts. The enlarger is very costly. It is supposed to be kept in the teaching aids room which has been moved down from the old resource centre. We have converted a few classrooms into teaching aids room. This is to enable the teachers to make teaching aids more easily.

R: What type of support you would like to provide the science teachers but have not been able to do so because of certain constraints?

Mr. Ong: We have to provide the teaching aids room. I am also trying to put some computers in the audio-visual room, and getting software in Chinese. We also have an audio-visual room which is quite comfortable. We still have to equip the audio-visual room like computer multi-media, CD-ROM for the teachers and pupils. They can view the topics that are related. It should be soon now that the room has the necessary equipment and is ready for use. Now we have the room already, we help the teachers once Internet is made available. We try to get software from countries like Taiwan and China where the medium of instruction is Chinese.

(S1:HT:P2)

Mr. Ong was generally satisfied with the performance of the teachers in the school. According to him, most of his teachers had the right attitude and could manage the class well without his intervention. Therefore, he did not consider it necessary for him to observe their teaching. So far, he had not observed his teachers in action in their classrooms. His "distant observations" could probably provide him with some information relating to the teachers' classroom management based on the noise level and the movement of pupils and teachers in the classrooms. It is unlikely that such observations would be able to provide much useful information regarding the teaching-learning process that was taking place in the classes.

Mr. Ong: Overall the teachers are OK. They do not need a lot of my supervision. I do not go into their classroom. Usually I do distant observations. I go around the classrooms and make sure that things are OK. Most of my teachers are OK. I always think it is not very nice. When they do not have any problem, when they can manage the classroom well, when they have the right attitude, I do not think we should worry about them.

(S1:HT:P3)

Mr. Ong admitted that he could not expect the teachers to implement the primary school curriculum effectively due to the many constraints. For example, with the large number of pupils in the class, he did not expect the teachers to do group work even though group work was very much the essence of the primary school curriculum for all subjects. He preferred the teachers to follow closely to the content in the textbooks rather than preparing their own teaching materials. This was to avoid making mistakes and to ensure uniformity for all classes in preparation for the UPSR examination.

> Mr. Ong: KBSR means teachers have to look for their own teaching materials. Teachers are not supposed to depend on textbook. They have to prepare their own notes. In this way, they have to do a lot of preparation which involve a lot of duplicating work. That means we have to use a lot of paper, ink, manpower. By doing that it will be more expensive than getting a textbook. Textbook is prepared by a group of so-called experts who are well versed in the syllabus and have experience in preparing materials and also who are very well versed in this field and very qualified. A lot of research has to be done. It needs time to prepare a textbook. The materials have to be checked and rechecked. For the KBSR, the teachers will have to find their own materials which are suitable for their own classroom. They will need a lot of time to look for materials. A lot of reference work has to be done. The teachers themselves have to be well versed in the field. We don't have expert teachers. We don't have specialist teachers. They are all ordinary teachers. To a great extent, we depend so much on textbooks which are plentiful nowadays.
>
> R: You mentioned earlier that because of the various constraints, you don't really expect your teachers to teach according to the KBSR way, that means you don't really expect them to teach according to pupils' abilities.
>
> Mr. Ong: No, I don't. I expect as far as possible they divide pupils into groups. I can't stress too much on that.
>
> R: You also mentioned that they depend a lot on the textbooks.
>
> Mr. Ong: It is safer to use textbook rather than preparing their own teaching materials. Who is going to check their mistakes? If teachers are not very well versed in the subject, they might teach very limited science knowledge to the students. If you have better teachers who have science background, who are well versed in science, they will teach more and give more materials to the students. Then the students will benefit. But then you don't have the uniformity. But if we have the textbook, we know where we are. We have some kind of guideline so that when it comes to UPSR examination which is a unified examination then we will not have so much problem. Otherwise the students' result will vary so much if we do not base on the textbook which is written according to the syllabus. We let the science teachers select the book to use. The teachers feel that the book by the ministry is not enough. They normally look for other sources for reinforcement.
>
> (S1:HT:P4)

Mr. Ong seemed to put great emphasis on pupils' performance in UPSR examination. In his address to the teachers as recorded in the minutes of the staff meeting, he said, "The science room will be set up as soon as possible because science has been included as an UPSR subject. ... The result of UPSR in our school has always been good. I hope that the teachers are looking forward to even better performances in the future". Overall, Mr. Ong seemed to hold a greater concern for achieving smooth operation of the school by using a highly structured administrative style than he did for the type of teaching-learning happening in the classrooms.

5.3 Head of Science: Mrs. Lim

Unlike most schools which had one subject head for each subject, Sin Hwa School has a subject head for each standard. Since science was taught in Primary Four, Primary Five and Primary Six, the school had three science heads. The responsibilities of the subject heads were specified in the school calendar and these included:

1. Conducting a meeting with the other teachers teaching the same subject in the same standard;
2. Planning the scheme of work for the year; and
3. Standardising the format of the lesson plans.

At the time of the study, Mrs. Lim was the Head of Science for Primary Four. She had not attended any of the three orientation courses on the new primary science curriculum nor had she been briefed by the teachers who had attended the courses. In fact, she had no idea as to which teachers, if any in the school, had attended these courses. She did not have the syllabus guide or the twelve curriculum modules published by the Ministry of Education which were distributed during these courses. It appeared that none of the other science teachers in the school had even ever seen these materials. Her only references were the textbook (Khor, 1994a), the teachers' guide (Khor, 1994b), and the workbook (Khor, 1994c) which were approved by the Malaysian Ministry of Education.

At the beginning of the school year, Mrs. Lim called for a meeting with six other teachers who were teaching science in primary four. As reported in the minutes of this meeting (S1:D4), she distributed the scheme of work for the year (Appendix K) to the teachers during the meeting. The scheme of work specified the topic to be covered for each week, the dates of the tests and examinations together, and the names of teachers who were to set them. After taking into account the holidays, the tests and examinations, she allocated one week for each of the topics (referred to as a lesson in the scheme of work) found in the textbook. Apparently, no consideration had been given to the complexity of each topic. During the meeting, Mrs. Lim also briefed the teachers on the need to teach according to the textbook and the teachers' guide and to closely follow the scheme of work provided. She also explained the format of the lesson plans and the format of the test and examination papers.

Mrs. Lim did not seem to consider it her responsibility as one of the science heads to exercise her leadership in organising science-related activities. There was no indication of any science activities planned for the year. She considered matters like setting up the science room and getting more charts, as the responsibility of the head teacher. She was hoping that a laboratory assistant, or the teacher in charge of the resource centre, would take charge of the science room.

R: Who is in charge of getting the charts?

Mrs. Lim: The headmaster is in charge of that.

R: Do you normally leave it to him?

Mrs. Lim: Yes. Of course we can give our suggestions.

R: Besides charts, what other teaching aids would you like to have? (No response from the teacher) Right now, the science things [science equipment and materials supplied by the Education Department] are still in boxes in the store room. Who is in charge of listing them down in the stock book?

Mrs. Lim: So far nobody has mentioned anything yet. Suppose to be one teacher.

R: There should be a stock book.

Mrs. Lim: And a lab assistant.

R: Do you have [a lab assistant]?

Mrs. Lim: I hope we will have.

R: If you do not have, probably one of the teachers has to do it?

Mrs. Lim: Who is going to do it? Everybody's lessons are so packed. Everybody is so busy. Do you think that is the job of the teacher in charge of the resource centre?

(S1:T1:I2: P1&2)

5.4 Case Study Teacher (1) : Mrs. Lim

5.4.1 Teacher's profile

Mrs. Lim had been teaching Chinese language and Mathematics throughout her 19 years of teaching in Chinese primary schools. She has also taught 'Man and His Environment' and the old science curriculum. Mrs. Lim was trained to teach Chinese Language and did not receive any training in teaching science throughout her teaching career except for the one week in-service course on 'Man and His Environment' many years ago. At the time of the study, her weekly teaching work load was 29 lessons consisting of 10 Chinese language lessons, 7 Mathematics lessons, 5 Science lessons, 5 Moral Education lessons and 2 Art lessons. She taught these subjects in Primary 4C where she was the class teacher. She was also the Head of Science for Primary Four as well as a teacher advisor for the Chinese Language Society in the school. She disliked the idea of having to teach many subjects as this involved more preparation and she considered herself overworked (S1:T1:I4:P5). However, she recognised the advantage of teaching various subjects in the same class. According to her, "It is good in one way because we have more time with our own pupils and know more about their character" (S1:T1:I2:P4).

Mrs. Lim considered herself as more dedicated and efficient when she was younger and her enthusiasm had since dwindled.

> R: Have your ideas of teaching changed over the years?
>
> Mrs. Lim: When I was younger, I was more dedicated and efficient. Now, there is more work and responsibility. Now that I have a family, I have more responsibility and burden. Last time, when I was single, there was less burden. We have many new ideas from the courses attended. Whatever we can do, we will do.
>
> (S1:T1:I3:P5)

Mrs. Lim studied Biology, Physics and Chemistry up to school certificate level and preferred Biology to Physics. She believed that possession of subject knowledge did not guarantee a teacher to be effective. According to her, an effective teacher must have the ability to explain clearly so that the students could understand. Since she was a pure science student, she had done practical work in the science laboratory during her school days. Pure science students had to sit for practical examinations which formed part of the examinations for these subjects. From the following conversation, it was obvious that her experience of science learning during her school days was that of the didactic approach, which was teacher-centred and the students' role was merely to listen to the teacher.

> R: Can you share with me your experience of learning science as a student?
>
> Mrs. Lim: I am from a Chinese school. I studied Biology, Chemistry and Physics in secondary school. I liked science. I hated Physics and preferred Biology.
>
> R: How did your teachers teach science?
>
> Mrs. Lim: Both my Biology and Chemistry teachers are good teachers but not the Physics teacher. The Physics teacher had a lot of knowledge. The way he talked, we cannot accept it. We can't understand. He did not explain much. He will talk and talk, stop and we do it ourselves. That is why I am not good in Physics.
>
> R: Did you do practical?
>
> Mrs. Lim: We have to do all the practical. It is part of the exam.
>
> R: Did you understand what you were doing during the practical?
>
> Mrs. Lim: In Physics, sometimes I did not understand. For Biology and Chemistry, they were OK.
>
> (S1:T1:I3:P1)

Mrs. Lim was teaching Man and His Environment before the new science curriculum was introduced. She saw the difference between the two subjects mainly in terms of their content with 'Man and His Environment' covering topics from History, Geography and Civics, and that the science content was nearly the same in both subjects. As for teaching methods, she saw the trend as being a shift from teacher-centred teaching to more pupil-centred and activity-based teaching.

> R: Did you feel any difference between the old science, science in 'Man and His Environment', and the new science now?
>
> Mrs. Lim: We do not have civics and local studies in the science syllabus.
>
> R: That is from the content. What about the teaching methods?
>
> Mrs. Lim: Last time, our teaching method is more chalk and talk. There were not so much activities. Nowadays, there are more activities.
>
> (S1:T1:I3:P1)
>
> R: You have taught Man and His Environment before. What is the difference between teaching Science and 'Man and His Environment'?
>
> Mrs. Lim: 'Man and His Environment' covers more topics which include History, Geography, Civics.
>
> R: It also has the science component.
>
> Mrs. Lim: It is less. The new science curriculum is more detailed, has more activities for them to think. For science components, they are about the same.
>
> (S1:T1:I2:P7)

5.4.2 Inside Mrs. Lim's classroom

Mrs. Lim had 53 pupils in her class, 45 of whom were Chinese while the other 8 were Kadazans and Sino-Kadazans. The pupils were seated in six groups with eight to nine pupils in each group. The room was congested with little space in between the groups. Various pupil-made charts consisting of mammals, birds, vertebrates and invertebrates, were displayed on the science section of the bulletin board at the back wall of the classroom.

Mrs. Lim taught 'Animal reproduction' in six lessons consisting of three double-period sessions. The first session focused on animals which give birth, while the second session was on animals which lay eggs. During the third session, pupils watched slides of sea mammals and a video recording of an educational television program on 'Animal Reproduction'. A summary of her lessons is provided in Table 5.2.

Mrs. Lim stood and spoke from the front of the room almost all of the time she was explaining and asking questions to the pupils. She would stay further back from the chalk board while the pupils were working at the board. While pupils were working in their groups, she would move around the room, checking on pupils' progress in their work, and providing assistance whenever necessary. Decisively in control of

Table 5.2: Summary of Mrs. Lim's Lessons

Session 1 (Lessons 1 & 2)	Mrs. Lim explained to the pupils (with questions interspersed) that under favourable conditions like availability of food, water and suitable environment, all animals can reproduce. Under unfavourable conditions, these animals may become extinct, for example, dinosaurs. Mrs. Lim referred pupils to the picture in their textbooks which showed various animals in a jungle scene and explained the importance of reproduction in ensuring the continuity of the species. With the help of a chart, Mrs. Lim introduced the various animal groups such as animals which give birth, animals which lay eggs, warm-blooded animals, cold-blooded animals, vertebrates, and invertebrates. Mrs. Lim then used the example of human beings to talk about the gestation period, the care of the new born baby in terms of food and care. Reproduction of cats and whales were also briefly explained. Mrs. Lim wrote the definition of the animals which give birth on the chalk board and the pupils copied them into their exercise books. Pupils took turn to write examples of animals which give birth on the chalkboard. After Mrs. Lim checked that the examples were correct, pupils copied them into their exercise books. Pupils completed charts of various animals which give birth in groups of 8-9 pupils. Pupils brought the necessary materials for the lessons
Session 2 (Lessons 3 & 4)	Mrs. Lim commended the pupils for the charts produced in session 1. Mrs. Lim explained the difference between soft-shelled eggs and hard-shelled eggs by using various examples. She showed them a chicken egg as an example of a hard-shelled egg. Pupils were asked to give examples of both types of eggs. Mrs. Lim explained that some animals like fish have to lay more eggs than others like chicken because chickens take care of the eggs and the new born while the fish do not. One pupil was asked to read aloud the autobiography of a frog from a magazine cutting provided by the teacher, followed by Mrs. Lim explaining the life cycle of a frog with the help of chart. She then explained the life cycles of bee and butterfly in a similar manner. Mrs. Lim hang up a chart containing a series of photographs showing the various developmental stages of a chick. She briefly explained the development of organs such as the eyes, the feather, heart and legs by referring to the relevant photographs. Mrs. Lim copied some notes on the important ideas taught in the lessons onto the chalkboard and the pupils copied them into their exercise books. The lesson concluded with the pupils completing charts of various animals which lay eggs.
Session 3 (Lessons 5 & 6)	Mrs. Lim showed slides of various sea mammals and a video recording of an educational television programme on animal reproduction. Teacher explained each slide / video picture as it was shown. A competition was held between the boys and the girls. The boys were to write down the names of as many animals which give birth and the girls were to write down the names of as many animals which lay eggs. Pupils completed the exercises in their workbooks.

her class, Mrs. Lim maintained a quiet and orderly classroom. Pupils seemed attentive and were eager to answer her questions. Although they did not ask questions in front of the class, many of them did not hesitate to approach her individually to get the 'correct' answers when they were uncertain of the answers. This occurred most frequently when the teacher walked around the class during group work.

Mrs. Lim followed closely the teachers' guide in determining the scope and sequence of the lessons taught. Suggested teaching activities in the teachers' guide as shown in Appendix L, were predominantly teacher-centred consisting of teachers telling or explaining to the pupils about certain phenomena. Pupils observation was restricted to the pictures in their textbooks and there was no suggestion of observation of animal specimens. Lesson objectives stated in the teachers' guide as shown in Appendix M, were knowledge-based and were of low-order consisting of stating definitions, giving examples, and classifying animals into various groups. There was no reference to scientific skills, thinking skills, scientific attitudes or moral values.

In accordance with the activities suggested for 'Animal Reproduction' in the teachers' guide, teacher explanation and question-answer dominated her lessons. Charts, both commercial and teacher-drawn, were the main teaching aids used. Neither the teacher nor the pupils brought in any animal specimens for investigation. In addition to the activities suggested in the teachers' guide, Mrs. Lim introduced various other activities in her lessons such as pupils writing the names of animals on the board, copying notes, reading an article on the autobiography of a frog from a children magazine, doing charts in groups, and viewing slides and video recordings. These activities had been used effectively to maintain a quiet, orderly and attentive atmosphere. Her effectiveness in communicating with her pupils was further enhanced by her ability to explain in a way the pupils found easy to understand.

Mrs. Lim seemed to encourage pupils' physical engagement in the various activities during her lessons. However, there appeared to be a lack of 'minds-on' participation despite the potential of the various activities being able to provide ample opportunities to engage pupils in the development of various thinking skills and scientific skills. For example, for the group work on doing charts about animals which give birth (S1:T1:O1:P4) and animals which lay eggs (S1:T1:O2:P4), Mrs. Lim ensured that all necessary materials were available. She also specified acceptable behaviour during the activity. The only task assigned to the pupils was to choose the pictures of the animals which give birth and to paste them on to the manila card. Co-operation was seen in the form of each member of a group contributed in bringing the required materials such as scissors, gum and pictures of animals, and in playing different roles such as cutting and pasting the pictures to get the chart completed. Mrs. Lim did not seem to encourage members of a group to work together to share their ideas and to debate or reflect upon them. For example, she could have encouraged them to share their ideas about the number of new born, care of the new born, the conditions of the new born, or some other features of interest. Pupils could also be encouraged to think of various ways of designing the charts. Charts from different groups, including those made in previous lessons on display at the bulletin board, were of the same format with the title on top and the pictures below it.

Another example of missed opportunity was the use of slides and video which was confined to the teacher explaining about each slide while the pupils listened rather passively. The slides and video were provided by the researcher. Please refer to page 82 and page 83 for further explanation on these slides and video. Though pupils showed much enthusiasm while viewing the slides and the video, once again Mrs. Lim did not provide an opportunity for them to share or to debate their ideas.

Further examples of missed opportunity could be seen from the way Mrs. Lim responded to pupils' answers. She used a lot of questions in her apparent effort to encourage her pupils to think. Most of the questions asked were of low-order convergent questions requiring 'yes' or 'no' answers or one or two-word answers. The followings are some examples of questions she asked in her first session: "Can the new born baby walk?"; "Does the mother have to care for the baby?"; "How many kittens are born at one time?"; "Can the newly born kittens walk?"; "What are examples of animals that give birth?". Similar types of questions were asked in the other sessions. As a result, questions which required the pupils to express their ideas in longer sentences were often met with little response. Apparently, pupils had not learnt how to communicate their thoughts effectively. This was revealed when they were faced with answering higher-order cognitive questions.

Occasionally, thought-provoking questions such as 'Why are there no more dinosaurs?" (S1:T1:O1:P1), and "Why do these animals [fish] have to lay a lot of eggs?" (S1:T1:O2:P2) were asked. For the first question, as soon as one pupil responded that they were starved to death, Mrs. Lim accepted it as if it was the only correct answer, and did not wait for other ideas or seek clarification on the answer provided. In the case of the second question, despite the teacher having cued the answer before the question was put forward to them, there was no response from the pupils. She went ahead to provide her answer without any attempt to rephrase the question or give some time for the pupils to think. The following excerpts show the two instances respectively. Mrs. Lim's lack of knowledge and understanding on questioning techniques seemed to have limited her ability to maximise the potential of these questions.

Mrs. Lim: Why are there no more dinosaurs, that is dinosaurs have become extinct?

P(i)[1]: Starve to death.

Mrs. Lim: Yes. The dinosaurs were very big. They needed a lot of food.

(S1:T1:O1:P1)

Mrs. Lim: Most of the fish, not all the fish as some fish do take care of their young ones. These animals lay their eggs and leave them to hatch on their own. The father or the mother do not look after them. They have to find their own food. Why do these animals [fish] have to lay a lot of eggs?

No response.

Mrs. Lim: They have to lay a lot of eggs so that the enemies won't be able to eat up all. If there are 100 eggs, 90 are eaten, there will be 10 left. If 50 are eaten, there will be 50 left. In this way, they won't become...

P(c)[2]: extinct.

(S1:T1:O2:P2)

From the observations of Mrs. Lim's lessons on animal reproduction, it appeared that she understood science to be a set of vocabulary and scientific terms that pupils needed to know. She repeatedly stated terms like egg-laying animals, animals which give birth, caterpillar, larvae and pupa. She made the pupils repeat after her, had these terms written on the chalk board, and asked the pupils to copy them into their exercise books.

5.4.3. Mrs. Lim's knowledge and understanding of science and science teaching

Teacher's understanding of the curriculum

Mrs. Lim admitted to having little understanding of the curriculum. In her own words, "If you ask me about the new science curriculum, I do not know much about it" (S1:T1:I2:P4). In her lesson plans, she put down thinking skills as asking questions, discussing and answering questions. She explained that since pupils had to think before they could provide an answer for a question, she had incorporated thinking skills in her lessons by asking her pupils questions, and getting them to give the answers. She did not relate thinking skills in more specific terms such as those

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[1]Indivudal pupil answered
[2]Pupils answered in chorus

described in the curriculum module on thinking skills. These include generating ideas, drawing inferences, relating, predicting, hypothesising, generalisation, using analogy, using mental pictures, creating, drawing conclusion, evaluating, analysing, preferential arrangement, sequencing, classification, comparing and contrasting, and characterisation.

> R (showing her the list of thinking skills in the syllabus): Which of the thinking skills are familiar to you?
>
> Mrs. Lim: These thinking skills are about the same. For example, I normally do this through questions and answers.
>
> (S1:T1:I3:P7)
>
> R: How do you incorporate the thinking skills in your lessons?
>
> Mrs. Lim: I ask them questions. I ask in between. I interpret it as the thinking skills.
>
> R: What types of questions do you ask?
>
> Mrs. Lim: Connected with the lesson.
>
> (S1:T1:I4:P3)

However Mrs. Lim believed that she was able to integrate the scientific skills and thinking skills into the science lessons as they were quite clearly spelt out in the teachers' guide. An analysis of the teachers' guide revealed that the guide did not mention anything about scientific skills and thinking skills. In fact, none of the objectives on 'Animal Reproduction' contained in the teachers' guide pertains to any of these skills.

> R: Besides knowledge, it [the primary science curriculum] also mentions about the scientific skills and thinking skills.
>
> Mrs. Lim: We write this in our plan for science lessons.
>
> R: Do you understand how to integrate these skills into the lessons?
>
> Mrs. Lim: The teachers' guide book is quite clear. I can understand.
>
> (S1:T1:I2:P6)

Mrs. Lim's understanding of moral values and scientific attitudes, were confined to co-operation and discipline which were also noted in her lesson plans.

> R; Do you think you could incorporate some values in your lessons?
>
> Mrs. Lim: Like co-operation and discipline, and like raising their hands when they want to answer.
>
> (S1:T1:I4:P3)

Mrs. Lim admitted that she had no knowledge of terms like 'constructivism', 'hands-on', 'minds-on' which were described in the curriculum modules on teaching-learning strategies (S1:T1:I2:P7). She had never expressed her concern about not having the curriculum guide and the curriculum modules, nor did she show any concern that she had not understood the curriculum fully. Her main concern seemed to lie with the aspect of curriculum relating to the content knowledge to be learnt by the pupils and the types of questions that would be asked in the UPSR examination.

> R: Now we shall talk about the new science curriculum. What is the requirement of the new science curriculum?
>
> Mrs. Lim: Actually I have not seen it. We are not that clear about that. What we learn from the textbook is not that much. They touch a little here and there. When we come to teach, the main problem is that we do not know how far we are asked to teach.
>
> (S1:T1:I2:P6)

> Mrs. Lim: When exam comes, that is the problem. If I teach a good class, I teach a lot. If I set the questions, I will set what I have taught. The other classes won't know how to answer the questions. I was discussing with the teachers. The teachers are worried. They don't know what the education department wants us to teach and what type of questions will come out. Only after a few years, we can trace the trend.
>
> (S1:T1:I2:P5)

Mrs. Lim did not find the textbook to be of much help. She commented on the inadequacy of the textbook (Khor, 1994a) as containing too many pictures with too little explanation. As a result, the teachers had the problem of not knowing how much to teach. However she seemed to be happy with the teachers' guide and had adhered closely its suggested teaching activities, treating it as the curriculum.

> R: Have you taught the old science?
>
> Mrs. Lim: That was long ago when I first came out from the teacher college. The textbook was thin and we could learn a lot. Nowadays the books are thick. There are a lot of pictures. Not much telling. I don't know what they expect us to look for, to tell the pupils, up to what limit.
>
> R: How do you choose what to teach?
>
> Mrs. Lim: Usually we refer to the teachers' guide. They touch a little bit. I do not know whether I am going to explain more or just up to that limit.
>
> (S1:T1:I4: P5)

Teacher's understanding of science teaching-learning strategies

According to Mrs. Lim, experiential learning would be the most effective way of learning science, and therefore science lessons should be pupil-centred involving more group work and more activities.

R: How different is teaching science compared to teaching other subjects?

Mrs. Lim: Science needs more activities, more group work compared to languages. For Chinese, we just let them do composition on their own and no outdoor activities.

(S1:T1:I3:P5)

R: What do you think is the most effective way pupils learn science?

Mrs. Lim: They should learn through their own experience.

R: What types of activities pupils enjoy most?

Mrs. Lim: They like outdoor activities.

(S1:T1:I3:P6)

When presented with the list of various science instructional strategies in one of the interviews, Mrs. Lim expressed her familiarity with these strategies except for role play and simulation. She talked positively on the strategies familiar to her. She tended to superficially link these strategies to pupils liking the activities. She did not relate any of the specific potential benefits relating to pupils' learning with regard to any of the instructional strategies that she talked about. The following excerpts show what she said about some of these strategies.

Pupils experiment has good effect. When I taught about air occupies space, I let them do it. They like it very much. I think it is quite good for pupils.

(S1:T1:I1:P1)

Teacher demonstration is also not bad. ... For teacher demonstration, I interpret teacher does the experiment for them. I use teacher demonstration especially when it is more difficult and complicated. They can't do it. I'll do it for them and show it to them. They are also interested but not as interested as when they do it themselves.

(S1:T1:I1:P1)

Project is interesting to do. Pupils like to do it. Last time when I was teaching 'Man and His Environment', I asked them to do the project about the physical map of Malaysia. I asked them to bring plasticine to do the model. I gave them about one month to do it and they managed to finish it. I divided them into four groups. Each group did one project. After that I gave them some competition and I gave marks to them.

(S1:T1:I1:P2)

Quiz is a good thing to do. I have done it a few years ago, two years ago. It was after the exam. I gave them a competition. The topic was on astronomy. They could get all the figures about those planets and stars. They can find more information than me. They liked it very much.

(S1:T1:I1:P2)

Sometimes I brought them to the library. They searched information on their own. They liked it very much because the books and magazines had attractive pictures. They liked it.

(S1:T1:I1:P3)

Despite the positive things she talked about the various strategies, Mrs. Lim admitted that she often used teacher explanation and seldom used any of the other strategies. She justified her frequent use of teacher explanation for the primary four pupils as she believed that they were not capable of searching for science knowledge themselves. Instead of guiding them to look for information from various sources, she seemed to believe that teachers should provide them the information.

> I find it is very important especially for those small kids. They need teacher explanation very much. They still depend on teachers a lot. When they are older, they can search for information by themselves. Especially when they are in standard five and standard six, we can ask them to search some topics on their own.
>
> (S1:T1:I1:P2)

In the interview-about-instances, when asked to give her views of using teacher explanation to teach about the breathing mechanism of animals, Mrs. Lim recalled how she used cockroaches and grasshoppers to introduce the pupils to the breathing process of these animals. She would provide the necessary information and the pupils would observe to confirm it. She did not give the pupils opportunities to carry out their own investigation.

> Mrs. Lim: I feel explanation is suitable. Generally, we always explain first before we do activities.
>
> R: Can you explain some of the activities?
>
> Mrs. Lim: I will show them charts or ask them to breathe or observe the animals. I asked them to bring cockroaches and grasshoppers.
>
> R: What did you ask them to do?
>
> Mrs. Lim: To look at the breathing organs.
>
> R: Did you ask them to look for these on their own?
>
> Mrs. Lim: No. I explained to them where they are and then they looked at them. I also asked them to do experiment. One or two pupils ran up and down the stairs. Their breathing rates are different. After exercise, our lungs are supposed to be working faster.
>
> R: Did you ask them to draw the breathing holes of the grasshoppers?
>
> Mrs. Lim: I told them to draw in their note book.
>
> R: Where are the breathing holes?
>
> Mrs. Lim: I told them they were on the abdomen.
>
> R: Did you introduce the terms to them?
>
> Mrs. Lim: Yes, terms like head, thorax and abdomen.
>
> R: Where did you find the breathing holes?
>
> Mrs. Lim: I told them that they were on both sides of the abdomen.

R: How many segments are there in the abdomen?

Mrs. Lim: I did not tell them about the segments. They are not in the textbook.

R: Did you ask them to count?

Mrs. Lim: No.

R: We could also ask them to count the number of segments. We can train them to observe more closely. Are all grasshoppers the same? How are they different?
(No response)

R: Did you ask them to bring fish?

Mrs. Lim: Yes.

R: What did you ask them to observe?

Mrs. Lim: They saw how they breathed using the gills.

R: Did they see the gills?

Mrs. Lim: They brought the live fish and did not bring the dead fish. Actually, I asked them to bring the dead fish and wanted to cut open for them to see.

R: May be they could just bring the fish gills from home.

(S1:T1:I3:P2)

Having to rush to finish the syllabus for tests and examinations, teaching too many subjects, heavy workload, demand on teacher planning, the large number of pupils in a class, conformity to low noise level, and safety concerns were given by Mrs. Lim as some of the constraints for not using more instructional variety in her science lessons.

R: From what you say, you seem to think that the various strategies have their own advantages. However, you also mention that you seldom used these strategies in your teaching. Why is it?

Mrs. Lim: We have to rush through the lessons. The time is not enough. All these strategies need a lot of time to plan.

(S1:T1:I3:P5)

Mrs. Lim: There are a lot of things to consider. Such a big school, classes are so packed. Like visits, we have to contact everything and have to take care of pupils. 10-20 pupils, no problem for us. Invited speakers, we have to contact everything. We are not only teaching science but also teaching a lot of subjects. Our lessons are so packed. Time is limited also. We have to rush to complete our syllabus. We have to finish what is in the book because there is exam every month. The test is the same for all classes in the same standard. If we are not rushing for the syllabus, we can do a lot of things.

(S1:T1:I1:P3&4)

Mrs. Lim: Our main problem is that we are not only teaching science but are teaching too many subjects. We cannot actually concentrate too much on science. Our workload is too heavy. Sometimes, we are not very well prepared to teach the lesson. We have to rush to finish the syllabus for the exam. Sometimes a lot of activities which we would like to carry out and we couldn't do. The other problem is the number of pupils in the class is too many, so crowded and when you carry out the activities, they tend to make noise and some of them can't really take part. Some will be neglected. This is my point of view. Another problem is when the pupils get too excited, it is not easy to control them. Discipline is another problem.

(S1:T1:I2:P1)

Mrs. Lim: Some are dangerous, for example having to use knives to cut things. In our school, they do not allow the pupils to bring knives to school. I will do it for them, cut for them.

(S1:T1:I1:P1)

Mrs. Lim: We have to face the responsibility, especially when we bring them out. When pupils are out, they are too free. It is difficult to control when the class is too big. We do not want any unfortunate things to happen.

(S1:T1:I2:P1)

Mrs. Lim: Games are a good idea too but we can only do it once in a while. The children will all be messed up and making noise. During the Chinese training, we did it once but not in science. Such a big school, and there are 50 pupils in a class. It is difficult to control them.

(S1:T1:I1:P3)

Use of Resources

Though Mrs. Lim recognised the advantages of using educational media such as slides, television programs and video tapes, the main teaching aids used in her lessons were charts. She cited the unavailability of relevant video tapes, not having access to the timetable showing the broadcasting time of the educational television programs, the television time not matching the lesson time, and the early closing time of the school resource centre, as reasons for not using them.

R: This instance is about the use of videotapes to teach the development of transportation.

Mrs. Lim: It is very suitable but to get the appropriate video is difficult. Charts are more readily available.

(S1:T1:I3:P4)

Mrs. Lim: I only use video and slides once or twice a year. Very seldom. The problem is getting the video tapes on relevant topics so easily.

(S1:T1:I1:P3)

R: I wonder whether the education TV program is still shown on TV.

Mrs. Lim: I do not know. Now our lessons do not coincide with the TV time. They never tape it also. We cannot have it. I did ask them to tape it. Nobody is in charge.

R: Can you get the school to buy empty cassettes to record?

Mrs. Lim: Can. Few years ago, I did ask for that but nobody was in charge.

R: Do you have the timetable for the TV education program?

Mrs. Lim: This year, I did not notice any. Our lessons do not coincide with the TV time. The time here is limited. It [the resource centre] is up to 3.00p.m.

(S1:T1:I4:P4)

Mrs. Lim did not attempt to record off air any of the relevant television programs which could be used in the classroom at anytime she wished. The State Education Technology Department which was responsible for the distribution of the timetable for the educational television program was only a few kilometres away from the school. She could make a telephone call to get a copy of the timetable. The education resource centre where teachers could borrow various teaching aids was also nearby. Apparently, she was quite happy using the charts that were available in the school, and did not attempt to get other materials to supplement the charts in her teaching.

> We do not have enough teaching aids like charts that match with our syllabus and our lessons. It will be better. Recently, the school did not buy any charts for science. The old charts belong to Man and His Environment and we are using the old charts.
>
> (S1:T1:I2:P1)

The researcher had observed that piles of charts were left on the floor in the teaching aids room. The researcher was told by a teacher that these charts were moved from the resource centre to a separate room, and were in the process of being rearranged. They were left in such conditions for the whole ten weeks of the study. Even though Mrs. Lim felt that the management of resources like the charts needed much improvement, she did not bring this matter to the attention of the school authority as she felt it was not a polite thing to do.

> R: Can you take the teaching aids freely?
>
> Mrs. Lim: I need to get permission from the teacher in charge. He will bring us to the room to take. It is very inconvenient. All the teachers have this type of feeling.
>
> R: Did you bring up this matter?
>
> Mrs. Lim: How do we bring it up? It is not nice. All the things are still in a mess. There are a lot of charts. I am wondering what is the best way to arrange the charts. Last time we used hangers. Now they say they will just pile it up. If it is like this, how are we going to look for the charts. The teacher in charge has a clerk to help her. She has less than 20 lessons. In fact she is quite free.
>
> (S1:T1:I2:P2)

The school had facilities such as the science room, the school library and the audio-visual room equipped with television, overhead projector, video recorder and slide projector. It appeared that these facilities were not being put to good use for teaching purposes. Mrs. Lim and the other heads of science could have worked together along with the other science teachers, to find ways to fully utilise the available resources, instead of seemingly waiting for directives from the Head Teacher. This should not have been too difficult as the Head Teacher seemed to be willing to provide support in getting the required materials.

> R: Do you feel the facilities and support in this school are enough?
>
> Mrs. Lim: In what way?
>
> R: In giving you materials, facilities. If you need something, will the school support you?
>
> Mrs. Lim: Not bad.
>
> R: If you need something, and you tell the head teacher, will he support you?
>
> Mrs. Lim: No problem.
>
> (S1:T1:I2:P5)

5.4.4 Summary

Though Mrs. Lim was the Head of Science for Primary Four, she had not attended any of the orientation courses related to the implementation of the new primary science curriculum. She did not have access to the curriculum guide and the modules. Her only references were the textbook, the workbook and the teachers' guide. As Head of Science for Primary Four, Mrs. Lim had carried out the role expected of her by the school administration to ensure that the teachers adhered to the school's guideline with regards to scheme of work, lesson plans and assessment system. She did not consider it as her responsibility to take initiative in planning activities which could help to improve science teaching in the school.

Mrs. Lim followed closely the teaching-learning activities suggested in the teachers' guide to make sure that she was teaching within the curriculum framework. She had also included various other activities in her lessons which could have provided ample opportunities to engage pupils in the development of various thinking skills and scientific skills. However, her lack of knowledge and understanding of inquiry learning, limited her ability to maximise the benefits of these activities in developing a meaningful understanding of the science concepts, skills, attitudes and values advocated in the curriculum.

Mrs. Lim spoke favourably of various instructional strategies and linked their benefits to pupils' liking and interest. She did not relate the benefits of these strategies in more specific terms pertaining to pupils' learning. However, she admitted that she preferred the strategy of teacher explanation as she believed that primary four pupils were not capable of looking for information on their own. She resorted to providing them with the information using teacher explanation instead of helping them to develop the necessary skills required in information seeking. Having to rush to finish the syllabus for tests and examinations, teaching too many subjects, heavy workload, demand on teacher planning, the large number of pupils in a class, conformity to low noise level, and safety concerns were given by Mrs. Lim as some of the constraints for not using more instructional variety in her science lessons.

Mrs. Lim's science classroom practice fell short of the inquiry learning as advocated in the curriculum. Most of her lesson time was spent in the whole-class mode dominated by teacher explanation interspersed with questions. No live or preserved animal specimens were used in the teaching of 'Animal Reproduction'. Teacher explanation was often done with the help of charts. She lacked understanding of effective questioning techniques required in inquiry learning. Most questions were of low-cognitive level requiring factual recall, with very few that required reasoning and interpretation. Even when higher order questions were asked, Mrs. Lim often proceeded with her explanation, and did not allow enough wait time for the pupils to think and express their ideas.

Her understanding of the curriculum requirements was restricted and inadequate. Mrs. Lim seemed to have translated some of the curriculum requirements to fit into her existing vocabulary. For her, thinking skills meant that pupils needed to think to be able to provide answers to questions while moral values and scientific attitudes were confined to co-operation and discipline.

5.5 Case Study Teacher (2): Mrs. Chan

5.5.1 Teacher's profile

Mrs. Chan, with 32 years of teaching experience, was the most experienced of the five case study teachers. She was a science student and studied Physics, Chemistry and Biology up to Malaysian School Certificate. Her teaching experience covered a wide range of subjects such as Chinese, Mathematics, Moral Education, Science, Art, Physical Education, Bahasa Malaysia, Man and His Environment and English. She was the class teacher of a 'weak' Primary Four class and her teaching workload added up to 29 lessons per week consisting of 5 Science lessons, 10 Chinese lessons, 7 Mathematics lessons, 5 Moral Education lessons, and 2 Art lessons. She was the class teacher of 4G where she taught these subjects. She was the Head of Mathematics for Primary Four as well a teacher advisor for the Chinese Language Society in the school. This was the second year that she was teaching the new science curriculum.

Mrs. Chan had been a science stream student not by choice as she was actually more interested in arts subjects than the sciences. According to her, during her school days, students did not have the option of choosing the subjects. 'High-ability' students were placed in the science stream and 'weak' students in the arts streams. Her science teachers required the students to underline important points in the textbooks. The teachers would then explain and give more notes which were to be memorised in order to pass the exam.

> R: Can you share with me your experience of learning science as a student?
>
> Mrs. Chan: I am from the science stream. I was actually not interested in science. I was more interested in the arts subject. I was put in the science class. The main thing was to pass exam. I am from a Chinese school.
>
> R: Can you tell me how your teachers taught science?
>
> Mrs. Chan: The method was very simple. The majority of my teachers were from China. They asked us to underline the important points in the textbook. Like in Biology, we studied by rote.
>
> R: Did they ask questions?
>
> Mrs. Chan: No. Very rarely because there was a lot in the syllabus. The teacher asked us to underline the important points, explained and gave us notes. In order to pass the exam, we worked hard to remember and memorise.
>
> (S1:T2:I3:P1)

Unlike many teachers who would prefer to teach the better classes, this was the third continuous year that Mrs. Chan has volunteered to teach the weak class. Mr. Ong, the Headmaster of the school, described her as a teacher "who is hard to come by these days". According to her, these so called weak pupils could learn with appropriate guidance from the teachers. She described teaching the weak pupils as challenging as well as rewarding, as she was able to provide these pupils with the attention they needed to improve their performance in the various subjects.

> R: I understand that you choose to teach the weaker class. Why is it?
>
> Mrs. Chan: I have also taught the best classes before. In my 32 years of teaching, I have taught very good and very weak classes. This class is not really very weak but a little slower than normal class. I personally think that they are weak not because they are not intelligent. There can be so many other reasons. Some of them are weak because of their family background and get very little attention from their parents. As a teacher, I have to try my best to help them and not leave them as such so that they can improve. It is challenging for me to help them to improve. For normal classes, it is easy to teach. You just have to introduce the concepts and they can do it on their own. I am also teaching Chinese and Mathematics in the same class. For Mathematics and Chinese, I need a lot of time. For Chinese, writing skills are very difficult to teach. Some do not even know how to make sentences even though they are already in primary four. There is a lot of pressure if you teach the good classes because the target is very high. It is not the percentage of passing but the percentage of A [grade for distinction]. Parents also put a lot of pressure. For weak classes, my target is not high. So at the end of the year, I can

always exceed the target. I feel I am quite successful in that sense. I have taught the primary three weak class and the primary four weak class and I found it to be very rewarding.

(S1:T2:I4:P1&2)

Mrs. Chan liked the idea of teaching various subjects to the same class as she found that by spending more time with them, she could understand them better and thus can help them more.

R: You are teaching a number of subjects in the same class. How do you feel about this?

Mrs. Chan: I feel they are very close to me as I have a lot of time with them. Almost all the form teachers are about the same. We teach the main subjects. We know them very well. Last year, I taught primary four pupils whom I have also taught when they were in primary three. I like it very much. I understand their character very well. I train them and they slowly develop eagerness to learn. Through questions, tests, competitions, we can know whether they have understood.

(S1:T2:I3:P5)

Mrs. Chan has been trained to teach Chinese and did not study any science during her teacher education course. Her impression of one in-service science course that she attended in the 70s was that of the stereotype where the lecturers talked and gave notes. She was of the opinion that courses should be realistic about the resources and facilities available in schools.

R: Have you attended any course related to Science or 'Man and His Environment'?

Mrs. Chan: Very rarely. That was in 1970s. It was the old science when they changed the syllabus.

R: Did you still have any impression of the course?

Mrs. Chan: No. I do not have much impression. The course was like the usual. The lecturers lectured and gave us notes. I have not attended any courses for a long time.

(S1:T2:I3:P1)

5.5.2 Inside Mrs. Chan's classroom

Mrs. Chan had 40 weak pupils in her class, 32 of whom were Chinese while the remaining eight were Kadazan and Sino-Kadazan. Unlike most other classes where pupils were seated in six groups with eight to nine pupils in each group, Mrs. Chan arranged her pupils to be seated in pairs forming four rows, all facing the front of the class. Various pupil-made charts of animals like mammals, birds, vertebrates and invertebrates were displayed on the science section of the bulletin board at the back wall of the classroom.

Mrs. Chan taught 'Animal reproduction' in six lessons consisting of one single-period session and two double-period sessions. The first single-period session was spent on animals which give birth, while the second session was on animals which lay eggs. The third session was a summing up session, with the first half of the session spent on pupils viewing slides of sea mammals and a video recording of an educational television programme on animal reproduction. Table 5.3 summarises the classroom events for her lessons.

Mrs. Chan's genuine interest and commitment in wanting to help her pupils in their study has helped to create a conducive learning atmosphere in her class. She was firmly in control of the class with no social behavioural problems. Pupils were keen to listen and responded to her in a relaxed and spontaneous manner. Routines in the class were well established so pupils knew what and when to do things. For example, they knew the appropriate moment for answering in chorus and when to raise their hands to give an individual answer. During the transition from one activity to another, the pupils acted as though they knew exactly what was expected of them, making the minimum noise, putting aside the materials for the previous activity, and getting ready those materials required for the next activity. Mrs. Chan also managed the use of voice intonation, eye contact and gesturing very effectively to captivate pupils' attention. Her eyes scanned the whole classroom ensuring pupils' participation despite her calling upon only the volunteers to answer her questions.

The quiet and orderly classroom atmosphere seemed to suit Mrs. Chan's teaching style. The class resembled a traditional setting with the teacher providing the information and the pupils listening to the teacher. Mrs. Chan used a teacher-centred style of classroom organisation and management with almost all the class time spent in the whole class mode. Like Mrs. Lim, Mrs. Chan also used the teachers' guide as the curriculum, adhering closely to the suggested activities in the guide. She spent most of the time of her lessons explaining specific content with the help of charts, and repeating the important ideas. This was interspersed with questions of low cognitive demand requiring recall of facts and questions requiring 'yes' or 'no' answers. Some examples are: "What are some examples of animals that give birth and live on land?"; "Does a chicken egg have an outer shell?"; "Do the insects give birth or lay eggs?"; "Where does a butterfly lay its eggs?". It was always the initiative of the teacher to ask the questions and pupils responded well to this. Pupils had never asked any questions in class nor had they been overtly encouraged to do so. She only called on volunteers to provide the answers. Non-volunteers were left on their own and no attempt was initiated to encourage them to answer questions. When she was asked in one of the interviews whether she provided opportunities for her pupils to communicate, she said, "Some of them are very quiet. Even when we ask them, they will not answer. Those who like to answer will always put up their hands" (S1:T2:I2:P4).

Table 5.3: Summary of Mrs. Chan's Lessons

Session 1 (Lesson 1)	Mrs. Chan explained the consequences of living things becoming extinct if they die without reproducing young ones. She explained how human beings were responsible for animal extinction and explained what Malaysian government has done to protect endangered species of animals and plants. She explained the meaning of reproduction and wrote the term reproduction on the board. Mrs. Chan gave the definition of animals which give live birth. She explained how the human foetus obtained air, water and nutrients from the mother. She compared the number of newly born of human, dogs and cats. Mrs. Chan introduced the term 'mammals' as animals which feed their young ones with milk.
Session (Lessons 2 & 3)	Mrs. Chan showed pictures of some marine mammals from a book. These animals included sea lions, walrus, whale. Mrs. Chan introduced them to the egg laying animals by using various examples. She provided various examples of eggs which have an outer shell and those without an outer shell. She also explained why fish have to lay more eggs than chickens. Mrs. Chan introduced the term amphibian. After explaining that amphibians refer to animals whose young ones live in water and the adult live on land, she explained briefly the life cycle of a frog. Mrs. Chan sketched a vertical section of a chicken egg to help her to explain how the embryo in a chicken egg obtained water, air and nutrients. She showed the chart which contained photographs of various developmental stages of a chicken egg and briefly explained the development of various organs at different stages. Mrs. Chan explained the life cycles of butterflies, frogs and bees with the help of charts. Mrs. Chan explained the difference between the life cycle of a frog and that of a butterfly. She also explained the similarities of the life cycles of butterflies, mosquitoes, bees and flies. Pupils, in groups of four, made charts of animals which give birth.
Session 3 (Lessons 4&5)	Mrs. Chan showed slides of various sea mammals and a video recording of an educational television programme on animal reproduction. Mrs. Chan explained each slide and video picture as it was shown. Mrs. Chan summarised the important points taught during the previous lessons on animal reproduction. Mrs. Chan went through the answers of the first few questions on animal reproduction in their workbooks. Pupils wrote the answers in their workbooks. She explained the rest of the questions and pupils were required to answer on their own. Pupils were given homework: Copy the diagrams of the life cycles of any two animals taught in their exercise books.

Even though most of Mrs. Chan's questions were of low-order type, she did ask some higher-order questions. Some examples of the higher-order questions she asked are: "Why do certain animals become extinct?"; "Why do fish have to lay plenty of eggs whereas chickens do not lay so many eggs?"; "Why are caterpillars harmful?". The following excerpts show her responses to the pupils' answers for two of the questions.

Mrs. Chan: Many animals have become extinct. Why do some animals become extinct?

P(1): Because they don't have children.

Mrs. Chan: (Repeating the pupil's answer) Because they don't have children.

P(2): Because it is very hot.

Mrs. Chan: Because it is very hot. Some animals have become extinct and some are decreasing in their number. This is because mankind wants development and they cut down forests which are the home of these animals. The environment becomes unsuitable for the survival of these animals. These animals have no home and cannot find food. Human beings also eat turtle eggs which are supposed to hatch into baby turtles. But we are greedy and eat the eggs. They hunt some animals for their meat, use their skin for bags and shoes, and that is why certain animals become less and less in number. Why are some animals becoming less and less? This is because we hunt them. Their homes are destroyed and they don't have enough food and therefore starve to death. For animals that live in the sea, the water becomes polluted and thus becomes unsuitable for them to live in. Now our government does not permit us to catch turtles. Malaysian government has reserved national parks to conserve animals and plants. It is illegal to remove animals and plants from these parks. In this way animals like tigers and elephants are protected.

(S1:T2:O1:P1)

Mrs. Chan: The egg hatches into caterpillar. Caterpillars can be of various colours like black, green or yellow. They look frightening. Are caterpillars harmful or useful?

P(1): Harmful.

Mrs. Chan: Why are they harmful?

P(2): It causes itchiness.

Mrs. Chan: If we don't touch it, it won't cause itchiness.

P(3): They eat leaves.

Mrs. Chan: Right. It eats a lot of leaves until it changes to pupa. Then it stops eating. It hangs on the tree branch and a lot of changes occur.

(S1:T2:O2:P3&4)

Mrs. Chan did not ask the pupils for clarification of their responses even when their answers were abrupt and vague. For example, she did not probe the pupil to elaborate on how heat might have caused the animals to become extinct. More pupils' responses could have also been elicited by providing more wait time. She did not respond to their answers nor did she relate her answer to the pupils' answers. Mrs. Chan presumed that the pupils could on their own compare the answer given by the pupils with that of the teacher, and would be able to judge for themselves whether their answers were correct or wrong.

> R: In your introduction, you were trying to explain why some animals become extinct. When you asked them for the reason, one pupil responded that it was too hot. What did you say?
>
> Mrs. Chan: I heard him but I did not say anything to him.
>
> R: How did he know whether his answer was right or wrong?
>
> Mrs. Chan: I feel he can compare his answer with that of the teacher and would find the answer given by the teacher as more correct.
>
> R: If a pupil gives a wrong answer, normally you will not say that it is a wrong answer?
>
> Mrs. Chan: It depends on the situation. In this case, he had a reason and the reason was related to the environmental change which I mentioned.
>
> (S1:T2:I4:P1)

In the second session of her lessons, Mrs. Chan used six minutes to explain the life cycle of butterflies, followed by a minute each to explain the life cycles of frogs, bees, mosquitoes and flies. Later in the stimulated-recall interview, she justified the rushing through much content in a very short time by explaining that she only tried to introduce the concept that insects undergo different developmental stages in their life cycles. She did not expect them to remember the different terms. However, she felt obliged to teach all of them because they were included in the textbook and the workbook.

> R: In your second and third lessons, you explained about the life cycles of butterflies, bees, frogs and chickens. Is it too much?
>
> Mrs. Chan: I think it is a lot. In the book, there are a few types like butterflies and bees. I tried to introduce the various developmental stages in the life cycles of insects. There are different terms for larva and pupa stages for different insects. Even though they may not remember them, at least they know that the insects undergo different stages.
>
> R: Do you think it is required by the syllabus?
>
> Mrs. Chan: It is in the textbook. The workbook also mentions about this. Therefore I feel I must teach them.
>
> (S1:T2:I4:P2)

Mrs. Chan continued to use her transmission model of teaching even in the session where her pupils watched video and slides related to animal reproduction. She provided information for the pictures on the video and the slides. The pupils' role was to watch the pictures on the screen and to listen to the teacher's explanation. The end of the slide or the video show marked the end of the activity. There were no follow-up activities where the pupils were given the opportunity for sharing and debate of ideas.

The only group activity for the topic involved pupils making a chart of animals which give birth during which time Mrs. Chan moved from group to group, responding to pupils' needs by providing answers when doubts arose to whether a certain animal gives birth or lays eggs. The cognitive demand of the activity was low, though pupils were active in cutting, pasting, colouring and labelling. Her justification for pupils to do this activity was that the activity was mentioned in the book. Moreover, according to her, cutting and pasting will help to reinforce their impression of the animals that give birth (S1:T2:I4:P2).

5.5.3 Mrs. Chan's knowledge and understanding of science and science teaching

View of nature of science

It was obvious from the conversation below that Mrs. Chan viewed science as primarily knowledge which all pupils could learn as long as they were fluent in the medium of instruction used in conveying that knowledge.

> R: The new science curriculum emphasises knowledge, scientific skills, thinking skills, manipulative skills and moral values. What do you consider as more important?
>
> Mrs. Chan: Content is fixed by the syllabus and is very important.
>
> (S1:T2:I4:P4)
>
> R: Do you use different methods to teach good and weak pupils?
>
> Mrs. Chan: For science, there is not much difference. Science generally deals more with knowledge. Like language and Mathematics, we divide them into groups.
>
> R: Do you think all the pupils can learn science?
>
> Mrs. Chan: All of them should be able to learn. If they understand the language, they should be able to accept.
>
> (S1:T2:I4:P5)

Teacher's understanding of the curriculum

Mrs. Chan had not attended any of the three in-service courses conducted for the science teachers since the implementation of the new primary science curriculum, nor had she been briefed by the teachers in her school who had attended the courses. She did not have the syllabus guide and the twelve curriculum modules. Like Mrs. Lim, her only references were the pupils' textbook, the pupils' workbook and the teachers' guide. Mrs. Chan's overall conception of the new science curriculum emphasis seemed to be in the direction of encouraging pupils thinking by involving them in activities. However, she admitted that she did not understand terms like 'inquiry approach', 'guided discovery', 'constructivist model of learning', 'hands-on' and 'minds-on', which were described in the syllabus and the teaching-learning strategies modules.

> R: What does the new science curriculum emphasise?
>
> Chan: The new science curriculum encourages pupils to think through the activities. The emphasis is on getting the pupils to do activities and think. In the old curriculum, the teacher gave the answers direct to the pupils. If you look at the activities suggested by the books, the pupils will do the activities and come up with a conclusion.
>
> (S1:T2:I2:P3)

Mrs. Chan did not demonstrate adequate understanding of scientific skills, thinking skills and moral values. For her, co-operation among pupils through various activities was considered as having integrated moral values into the lesson (S1:T2:I2:P3). Mrs. Chan did not seem to regard her lack of understanding of these skills and values as constraints from integrating these skills into her lessons. Time and workload were repeatedly given as reasons for not doing so.

Parents' and head teacher's expectations override all

Mrs. Chan's priorities in deciding what and how to teach were oriented to fulfilling the needs of the parents and the head teacher who used pupils' performance in examinations to measure teachers' performance. As pupils' poor performance in examinations was often blamed on either the teacher not finishing the syllabus or the teacher's inability to teach well, she would make sure that the portion of the syllabus to be assessed for each test or examination would be covered somehow. In her words, "... If you do not cover one topic, parents will complain that the teachers do not finish teaching and the teachers get the blame. Sometimes, before I finished one topic, I went on to the next and came back to revise the two topics together. Then at least I have covered all the topics" (S1:T2:I4:P3).

> R: The parents, head teacher want good exam results. The curriculum has the aim of producing thinking pupils. Which one has the greater pressure on the teacher?
>
> Mrs. Chan: Normally we follow the needs of the parents and the head teacher. If the pupils do not perform well, I feel that it is either the teachers do not finish teaching or the teachers cannot teach properly. To avoid all these, we rush to cover the syllabus.
>
> R: Your emphasis is on the marks scored by the pupils. It does not matter much whether they have the interest to learn.
>
> Mrs. Chan: It is of course important to train the pupils to think scientifically. Marks is the reality. The parents send the children for tuition every where after school. The aim is to get good results. They do not care about the teaching methods - even if it is learning by rote. For example, they even memorise the composition. When I was teaching in Kuala Lumpur, the

head teacher required us to ask pupils to memorise. Every week they would memorise one composition. There are so many sample compositions - English, Chinese and Malay.

(S1:T2:I1:P3)

Mrs. Chan believed that unless and until parents and school management changed their emphasis on marks, teachers would continue to succumb to the pressure of getting pupils to score high marks in the standardised examinations. Many teachers believed that the way to do it was through teacher explanation and not wasting too much time on activities. According to her, this problem was further aggravated by the State Education authorities who imposed their target on individual schools each year.

R: How do you think we can convince the teachers to use different approaches in teaching?

Mrs. Chan: It is not one person's effort. Parents should not put so much emphasis on marks. The school management should also be like that. The education department will determine the target for UPSR. The head teacher announced the target the other day.

(S1:T2:I1:P3)

Repetition and revision improve performance

Congruent with her view of science being a body of knowledge, Mrs. Chan interpreted her role as a teacher was to translate this knowledge into a comprehensible form, and present them clearly so that the pupils could absorb them easily. Mrs. Chan believed that repetition of important points is an essential ingredient in ensuring that pupils do well in the examinations. She related her success based on her own experience of teaching weak pupils. She also believed that repetition was particularly helpful for weak pupils who very often could not pay attention at all times, and therefore would miss part of the explanation. Repetition increased the probability of pupils' listening which could improve their performance in the tests and examinations.

R: How do you make sure they can do well in the exams?

Mrs. Chan: We repeat the important thing over and over again. Do revision. The passing rate is very high. In the previous monthly test, there was only one failure, that is 98% passed in their science. A lot of them do not study when they go home. What they remember is what they hear from the teachers during the lessons.

(S1:T2:I3:P5)

Mrs. Chan: The role of teachers is to impart knowledge and skills. We hope pupils can absorb the knowledge. Sometimes, the way we transmit knowledge may not be very good and some pupils may not pay attention. So we cannot expect them to absorb everything that we tell them. So I always repeat the same thing many times. Some pupils cannot concentrate for too long.

(S1:T2:I4:P4)

R: If it is a better class, would you teach in the same way?

Mrs. Chan: Most probably I will not explain in such detail. I will repeat many times since I know that my pupils may not listen the first or second time. I know that from my experience and I have to repeat many times. For a good class, I do not need to repeat and we can introduce more materials.

(S1:T2:I4:P2)

Activity approach as time consuming

Mrs. Chan acknowledged that her pupils enjoy doing activities and believed that strategies such as discussions, experiments, acting, games and quizzes were good, and should be used to arouse pupils interest in science. However, she regarded this approach as ideal, and acknowledged that teachers faced a lot of problems in carrying them out.

For Mrs. Chan, a lot of classroom time was taken up by tests, examinations and revision, thus leaving little time for actual teaching. According to her, examinations, tests and revision took up 16 weeks out of a total of 40 weeks school days which left 24 weeks of school days for teaching purposes. Therefore time became her main constraint for not including more activities in her science lessons.

Mrs. Chan: Our syllabus is very packed. Moreover our school has tests which will take one week or to be more exact three days. If your lessons happen to fall within the three days, it means you miss the whole week lessons. In addition to that, normally the week before the test is meant for revision. I do that but I do not know about the other teachers.

R: Does that mean that for each month, the teacher is left with about two weeks of teaching?

Mrs. Chan: In my former school in Kuala Lumpur, we had three tests and one exam for the whole year. We don't have to rush so much. In this school, we have six tests and two exams for the year.

(S1:T2:I4:P3)

Mrs. Chan felt that activities took up too much lesson time and therefore she would only use them when there was extra time. She would use them for topics with few concepts to teach and for those heavily content-oriented topics, she would spend all of the time to explain the many concepts, and therefore had no time to include any activities. In the common scheme of work used by all the primary four teachers who taught science, each topic was allocated a week (5 lessons) independent of the complexity of the topic.

Mrs. Chan: When I taught the movement of the animals, pupils came out to act. They liked it very much. The topic is very simple - so there is time to do activity. For some topics, there is so much content that we have to rush to teach it in the five lessons.

(S1:T2:I2:P2)

Mrs. Chan was of the opinion that teachers had to spend a lot of time in the preparation of the activities. As the teachers of this school were generalist teachers, most of them taught a wide range of subjects. She taught Chinese, Mathematics, Art and Moral Education in addition to Science. As such, she was not able to devote too much time on preparing for teaching science alone. Moreover, she did not consider science as an important subject in the school. She explained that only marks obtained in Mathematics, English, Chinese and Malay were used to determine the pupil position in the class and for promotion into better classes, and only the marks of these four subjects were on display on the staff room notice board (S1:T2:I1:P2). At times, she even used science periods to teach 'the more important' subjects like Mathematics and Chinese (S1:T2:I1:P3).

Teacher's confidence and competence

Mrs. Chan described her confidence in her science knowledge being based on her experience in having taught the same topics in the old science curriculum and 'Man and His Environment' (S1:T2:I4:P5). For teaching methods, she admitted that she merely followed those activities suggested in the teachers' guide and did not initiate other activities.

Mrs. Chan seemed to be confident of her content knowledge on animal reproduction. She fluently explained the concepts of the foetus in the mother's uterus, and how the chicken embryo obtains air, water and nutrients. These concepts were not contained in either the textbook or teachers' guide. However, the content of the rest of the lessons was determined by the teachers' guide, textbook and workbook.

Use of resources

Mrs. Chan used charts frequently in her lessons despite being aware of the many advantages of television, video and slides over charts. Her main reason was that charts were more readily available.

> R: You spent one lesson to let the pupils view the video and slides. What do you think about video and slides?
>
> Mrs. Chan: Their impression from the video will be deeper than those obtained from the pictures.
>
> R: What about the educational TV program?
>
> Mrs. Chan: In my previous school in Kuala Lumpur, the school arranged the timetable in such a way that each week, the pupils could watch the program at least once for the subject. Here, up to now, there is none.

R: What was your purpose of showing video and slides?

Mrs. Chan: The most convenient is the chart or the teacher drawing on the chalk board. For television, there is explanation, movement and alive which can arouse pupils' interest in learning. Slides are also good even though there is no movement. I prefer TV compared to slides.

(S1:T2:I4:P3)

When asked to comment on the use of a videotape to teach the historical development of science and technology in the field of transportation, Mrs. Chan said, "If there is video related to this topic, it is good and I will use it. ... Otherwise, I will use charts. For transport, in ancient times, they used horse carts and man-pulled carts. We have charts and some of them are found in the book. Normally it is like that" (S1:T2:I3:P3).

Mrs. Chan also talked about the problems of getting live specimens for her lessons. In reality, it would be a lot to expect teachers to look for the specimens. She seemed to restrict choices to the animals mentioned in the textbook. For example, since cockroach was not mentioned in the textbook, she would not use it even though it was more readily available than the other animals. She was also concerned about the safety of pupils involved in looking for specimens like tadpoles.

R: Have you thought of bringing in living things for your lessons?

Mrs. Chan: I have thought about cockroach eggs but I forgot about it. I have planned to explain about cockroach because their young ones look like the mother. The cockroach is different in that it only undergoes 3 stages instead of 4 stages. I find it difficult to find.

R: Do you think the pupils will bring if they are given enough time?

Mrs. Chan: The pupils mentioned that they have seen cockroaches in the cupboards. I did not think of asking them to bring. The textbook does not mention specifically about cockroaches. It depends on the pupils. In good classes, if teacher asks them to bring, they will bring. In my class, I asked them to collect pictures of animals. It took them a long time and still they did not collect much. I think it is more important to use the pictures and divide them into those which give birth and those which lay eggs. In my class, if I ask them to bring, sometimes they bring. Sometimes they do not bring. They will bring only if they have them at home.

R: I feel it might be a bit difficult for the teacher to bring everything. But if pupils can co-operate, for example like bringing tadpoles, it would be good.

Mrs. Chan: Yes. If you ask them to bring tadpoles, they have to get them from the water. There are a lot of mosquito larvae in the drain. If some accidents happen when they try to get these specimens, teachers will get the blame. It has happened in this school before and we want to protect ourselves. We find it difficult to explain to the parents if some accidents occur.

(S1:T2:I4:P4)

Mrs. Chan believed that there was plenty of room for improvement in the management of resources in the school. According to her, these resources should be catalogued and arranged systematically, to enable the teachers to know what materials were available and to be able to gain access to them easily. She related her experience in her previous school where the teaching resources were organised more systematically.

> Mrs. Chan: Because we are very busy. If we need something and require a lot of time to look for it, probably we will not use it. If those in charge catalogue it properly, we could find it immediately when we need to use it. If they are properly arranged, it will really help us. Sometimes we do not know whether they are available. There is no catalogue, even though there is a teacher in charge of the library, TV, video and teaching aids. He mentioned that he needed the help of the head of the various subjects to arrange the things.
>
> (S1:T2:I2:P2)
>
> Mrs. Chan: If you have to waste time to look for it, quite likely you are not going to use it. The place is not taken care of and is dirty. Last time we went to look for a few charts, we were dirty all over.
>
> (S1:T2:I2:P2)

Summary

Just like Mrs. Lim, Mrs. Chan too had not attended any of the three in-service courses conducted for the science teachers. As she used the same reference materials as those used by Mrs. Lim, her classroom practice was very similar to that of Mrs. Lim's. Mrs. Chan too used a teacher-centred style of classroom organisation with most of the class time spent in the whole class mode. Teacher explanation with the help of charts interspersed with questions, dominated her science lessons. According to Mrs. Chan, activities such as discussions, experiments, acting, games and quizzes were good and ideal, but were unrealistic. She was of the opinion that teachers would face a lot of problems in adopting such approaches, especially in terms of lesson time and workload.

Her questioning techniques fell short of what was expected in an inquiry approach to learning. Most of her questions were of low cognitive demand mainly emphasising factual recall. When higher-order questions were asked, she would provide her answers rather than providing opportunities for the pupils to share their ideas. Even when using slides and video tapes, Mrs. Chan continued with her transmission model of teaching by providing information on the pictures shown on the slides and video tape and did not provide opportunities for pupils' cognitive engagement.

Mrs. Chan's personal experience of science learning was one of the traditional approach where students rote learned the important science concepts to pass examinations. She seemed to be using the same approach in her science teaching.

Mrs. Chan regarded repetition and revision as crucial in ensuring pupils' success in examinations, even more so with the weak pupils. Important ideas were repeated many times during her explanation, and she would allocate one week before a test or examination to do revision with the pupils. She believed that this approach has worked well for her pupils as shown by their performance in the tests and examinations.

Mrs. Chan also lacked proper understanding of the scientific skills, thinking skills, moral values and scientific attitudes emphasised in the curriculum. She did not seem concerned about not having the curriculum guide and the modules, nor did she express her concern for not having clearly understood the curriculum requirements. However, her genuine interest in wanting to help her pupils to improve, her effective use of voice intonation and gesturing together with her pleasant composure, together with her many years teaching experience, had helped to create a conducive environment for learning in her lessons. Her pupils were keen to listen to her and responded to her in a relaxed and spontaneous manner. She was firmly in control of the class with no social behavioural problems.

Mrs. Chan was an experienced teacher who has won the respect of her pupils and the head teacher in the school and probably that of many others in the community. She has established her own ideas of what was best for her pupils through her many years of experience, and she seemed satisfied with the performance of her pupils resulting from her conservative teaching style. Consequently, there was no urgency or motivation for her to change her teaching style to that of a more progressive and liberal approach as required in the curriculum. Her adherence to traditional forms of instruction that emphasised factual knowledge at the expense of deeper levels of understanding are inconsistent with the inquiry approach of teaching and learning.

Learning orientation is strongly influenced by the orientation of the teacher. This implies that teachers have the means to influence pupils toward inquiry learning. From what was seen during the lessons, Mrs. Chan was trying to transmit factual knowledge as clearly as possible to her pupils. However, she provided very little opportunity for her pupils to participate in inquiry learning. If this trend continues, the pupils would in fact get used to 'listen to the teacher' style of learning, and would never become the self-reliant learners as wished for in the new science curriculum.

CHAPTER SIX
CASE STUDY REPORTS (PART II)

6.1 St. Elizabeth National Primary School

St. Elizabeth Primary School was first established in 1923 as a missionary school. At the time of the study, the school had 25 classes. It was a girls' school with an enrolment of 1127 pupils consisting mainly of Kadazans, Sino-Kadazans, Malays, Chinese and Indians. The classes ranged from primary one to primary six. All standards were streamed into four classes A, B, C and D where A was the 'best' class and D the 'weakest' class. All classes had about 50 pupils with the exception of Primary Six which had an E class consisting of 20 'weak' pupils. The school had 53 teachers with 4 supporting staff. Forty-nine female teachers and four male teachers made up the teaching staff, three of whom were untrained while the rest were trained. Like Sin Hwa School, the classes here were also organised in two sessions. Primary Four, Five and Six classes were in the morning, while Primary One, Two and Three classes were in the afternoon. The class time table was very similar to that of Sin Hwa School. However, co-curricular activities were held on Saturday mornings.

St. Elizabeth Primary School has been one of the top three schools in Sabah for the past three consecutive years based on the performance of the national primary six assessment. It had also been once awarded the model school of Sabah, and had been conferred one of the top places in the primary urban schools national award recently. The school attracted a large number of pupils from high socio-economic status families. According to the Headmistress, 80% of the pupils had at least one parent who was a professional. Consequently, the school was able to get substantial financial support from the Parent Teacher Association to buy various equipment and resources besides the normal allocation from the State Education Department.

The school had 16 classrooms, a school office, a staff room, a conference room, a resource centre, and three specialist subject rooms. The specialist subject rooms included a science room, a music room, and a room for Islamic Studies. In all classrooms, bulletin boards for display of pupils' work were fitted at the back wall and on both sides of the chalkboard at the front wall. While primary six pupils were seated in single rows, pupils of other classes were observed to be seated in six groups with eight to nine pupils in each group. Unlike their colleagues in Sin Hwa School, the teachers here did not have the luxury of an air-conditioned staff room. Otherwise, the set up of the staff room was similar to that of Sin Hwa School, with each teacher's work space consisting of a table and a chair. The Head Teacher and the two Deputy Head Teachers had their own air-conditioned rooms. The air-conditioned conference room was the venue for staff meetings and various committee meetings.

The resource centre consisted of a library and a teaching aids room. A television, a video recorder and an overhead projector were available, but there was no sign of any subject-related software. The library was well stocked with various types of books both in English and Bahasa Malaysia including a few sets of science encyclopaedia in both languages. The school pupils' preference for books seemed to be similar to that of Sin Hwa School. Story books were popular with the pupils while encyclopaedias and books with factual information were the least popular. Teachers too seldom used the books in the library. Charts were the main items in the teaching aids room.

The school science room has been modified from a normal classroom and was situated on the third floor of the building. The room had a sink at one corner of the room, with built-in storage cabinets and drawers along one side of the room. Desks were clustered in eight groups of six to form eight work benches. A row of desks were arranged along the back wall of the room, on which were placed three plastic aquariums with a few fish in each of them. A few commercial charts of animals decorated the wall at the back, and laboratory safety regulations were pinned on the wall at the entrance of the room. According to Pn. Jane, the Head of Science, the science room was rarely used. She said, "May be once or twice a month. Sometimes we don't use it for the whole month. The teachers do not like the room as it is small and not very comfortable" (S2:T1:I5:P1).

The school maintained a high discipline profile for both teachers and pupils. The minutes of one of the staff meetings reported the headmistress telling the teachers to be tolerant of each other, to follow the directives of those in authority like the headmistress, the senior assistants, the afternoon supervisor and the subject heads under all circumstances (S2:D5). Similar advice was reported in another meeting (S2:D4). Looking after the cleanliness of the school and discipline in and out of school, with particular emphasis on respect for their teachers, were emphasised in one of the weekly assemblies which the researcher attended. Classroom cleanliness competition was held weekly and the results was announced at the assembly. The pupils from what was judged the 'dirtiest' classroom, were given the task of cleaning up their classroom and the school compound after the assembly, under the supervision of the teachers. Generally the pupils were well disciplined. On entering the school compound during lesson time, pupils could be seen seated at their respective places, either listening to the teachers or doing individual work. Teacher's voice stood out conspicuously from almost all classrooms, and pupils' voices were hardly to be heard.

The desire to stay among the top performance schools in the state seemed to have put tremendous pressure on the headmistress, the teachers and the pupils. Minutes of the various staff meetings and curriculum meetings revealed that every effort was put into maintaining and improving the pupils' primary six national assessment performance, targeting a 95% pass with 50% distinctions in all subjects. Unlike Sin Hwa School where extra classes were held for pupils of all standards, here, extra classes were held for primary six pupils only. These classes were conducted two afternoons per week, on Saturday mornings, and during the school semester holidays. Teachers from the school received no extra pay to conduct these classes. Extra effort was put in to help the pupils who were identified to have serious learning problems. The Headmistress personally suggested increasing the number of 'drill and practice' exercises to help these pupils to pass the exam. In addition, one of the two weekly periods of Physical Education, a non-UPSR subject, was used for the pupils to concentrate on UPSR subjects. Teacher aides were also allocated to the weak classes 6C and 6D to provide pupils with more individual help. Despite 6E being the weakest class, teacher aides were not allocated as it had only 20 pupils compared to 50 pupils in the other classes. A motivation seminar had also been organised for all primary six pupils.

Various school activities for the year were spelt out in the school calendar (S2:D1). They included tests and examinations, staff meetings, curriculum committee meetings, co-curriculum meetings, and other major school activities like school sports day, Parents-Teachers Association meetings, school prize giving day, teachers' day, and meetings with parents. Six tests and two examinations for all subjects were planned for the year 1997 for primary one to primary five pupils. Primary six pupils had to sit for five tests, one examination, a trial school-based UPSR exam and the national UPSR. Nine staff meetings, seven curriculum committee meetings and five co-curriculum meetings, were scheduled for the year. Fifteen committees were set up to ensure smooth administration of the school, among which were the School Disciplinary Board, the Resource Centre Committee, the Board of Prefects, and the School Cleanliness and Beautification Committee.

6.2 The Headmistress: Pn. Doris

Pn. Doris had been a primary school teacher for 19 years teaching Mathematics and English before she was appointed as the Headmistress of St. Elizabeth Primary School in 1986. As the Headmistress of a 'high performance' school, Pn. Doris was very much involved in the various committees at the district and state level organising activities for pupils, teachers and head teachers. Among them were inter-school sports, inter-school mathematics quizzes, inter-school speech competitions, and head teachers' conferences. She was also the chairperson of a number of her school committees, for example, the School Planning Committee, the School Disciplinary Board, the School Cleanliness and Beautification Committee, the Curriculum Committee and the Co-curriculum Committee.

Pn. Doris attributed the success of the school to the commitment, dedication and co-operation of the teachers, the pupils and the parents.

> There is no real secret. The teachers have worked very hard and they have been very committed. I have been blessed with a group of teachers who are determined to do their best to help the children as much as they can. The teachers have given extra classes for the children. We have worked as a team. There will be five primary six classes who will be sitting for the primary six assessment test at the end of the year. Normally the teachers will have regular meetings. For example, there are three science teachers teaching the five classes of primary six. They do not work independently, but rather they work as a team. They discuss what topics to teach and the best approach. It is just hard work on the part of the teachers and the co-operation from the parents and of course the students themselves work very hard.
>
> (S2:HT:I1:P1)

Pn. Doris believed that specialised teachers made better teachers and this was clearly reflected in the school practising the specialist teachers concept. Here, teachers concentrated on teaching one or two subjects rather than teaching a wide range of subjects. Two of the teachers participating in the study taught only science while the other teacher taught science and local studies.

> Because I found through my years as the head of the school and also my experience as a teacher for about thirty years, when a teacher specialises on a certain subject, they are better teachers. Rather than you ask them to teach five subjects, they have to prepare for five subjects. The teachers in the schools are given one subject, two subjects, at the most three. They will be strong in the content. Even though they do not have specialised training like the secondary teachers, I feel that it is better. It is easier for the teachers.
>
> (S2:HT:I1:P2)

As for the allocation of teachers for the various subjects, Pn. Doris admitted that science was given low priority compared to Mathematics and English. She said, "Science being a new subject, we make use of whoever are available" (S2:HT:I1:P3). Even though she believed that teachers with science background could do the job better, she could not allocate these teachers to teach science as they happened to be also good teachers of English and Mathematics. Eventually only one of the five teachers teaching science had strong science background. Pn. Doris admitted that there was much room for improvement as far as science teaching in the school was concerned. However, she did not put the blame on the science teachers as she realised that these teachers did not have strong science background. According to her, good science teachers had the same characteristics as good teachers of any other subjects. She described these characteristics as interest, motivation, self-initiation and innovation. In her words,

> First the teacher must be interested in the subject and she must be self motivated, initiative and innovative. I feel that a science teacher needs not wait for directive from anybody. For instance, if they need certain equipment, if they need certain specimen, they have to go and look for it, ask for it rather than wait. It comes to initiative. If they are not interested, it will be a burden, it will not be a joy teaching the children. Somehow, the feeling will be passed on to the pupils.
>
> (S2:HT:I1:P3)

On a number of occasions, Pn. Doris was seen standing outside her office to have a good view of what was happening in the classrooms. All the three case study teachers seemed to think that she disapproved of noise, and therefore would avoid activities where pupils were likely to create a noisy atmosphere. As reported in the minutes of one staff meeting (S2: D5), Pn. Doris pointed out that pupils in some classes were making too much noise even though the teachers were with them and advised the teachers to control the pupils. However, in the feedback on the study report, Pn. Doris clarified:

> In fact, I encourage teachers to build the confidence of the children by getting them to talk and be open. What I disapprove of is unnecessary noise and unsupervised children who tend to be very noisy, thus disturbing the other classes.

Pn. Doris was seen by some of her teachers as the figure of authority which was to be revered. According to the participating teachers in the study, she did not mingle freely with the teachers, thus giving the teachers the impression that she was arrogant and unapproachable.

6.3 Head of Science: Pn. Jane

In St. Elizabeth Primary School, one subject head was appointed to co-ordinate the activities for the subject for all classes. Altogether, there were eleven subject heads for the eleven subjects which included Bahasa Malaysia, English, Mathematics, Islam Religious Studies, Moral Education, Art, Physical Education, Music, Manipulative Skills, Science and Local Studies.

Pn. Jane carried out the duties of the Head of the Science as expected of all subject heads. For long-term planning, she had planned science-related activities for five years which were included in the school's strategic planning five year plan 1994-1998

(S2:D8). She had also prepared the 1997 annual plan for science (S2:D9) with information on the organisation chart for the science curriculum committee, dates of the science meetings, targeted passes in science for UPSR, dates of monthly tests and semester examinations with the names of teachers responsible for setting the individual test and examination paper, and various activities for pupils. These activities included competition of planting plants which reproduce using seeds, preservation of plants, poster drawing competition, interclass quizzes, setting up a science garden, and recycling of waste materials competition. In addition, there was also plan to equip and beautify the science room by introducing activities such as drawing posters, planting, preservation of animals and setting up a reading corner.

Pn. Jane seemed to have done what was required of her as the Head of Science in the school. At the time of the study, she had held three science meetings as scheduled in the yearly plan. The stock book was up to date with all the equipment and materials supplied by the education department. The equipment and materials in each of the drawers and lockers were labelled. Pn. Jane also ensured that the science lab was presentable at all times. Charts were used to decorate the wall behind the lab and desks were lined with decorative plastic sheets. Safety regulations were displayed clearly on the wall. Prior to each interview session, she would request a few minutes to change the water in the aquariums in the lab. She explained that she was unable to assign this task to the pupils as their timetable was packed. She had co-ordinated all tests and examinations by making sure that the test and examination papers were set according to the format required.

While Pn. Jane was able to carry out effectively the administrative and custodial duties as described above, she was less efficient in delegating the responsibilities to the other science teachers. At the time of the study which was well into the first half of the year, none of the activities planned for the year had yet been carried out. No dates were set for the activities and no teachers were assigned to take charge of the activities planned.

As Head of Science, she was required to evaluate the teaching of science teachers when called upon to do so by the Head Teacher. She recalled her observation on one of the teachers who made some mistakes in her lesson. She admitted not telling the teacher concerned about the mistake as she regarded it as improper for her to critique her colleagues.

> There was one primary four teacher teaching on the topic 'time'. She was showing the clock and told the pupils that the 'hour' needle is longer than the 'minute' needle whereas actually the minute needle is longer than the hour needle. I did not tell her the mistake because sometimes I also can make mistakes. I do not like to comment. She may think that I want to show off.
>
> (S2:T1:I5:P1)

Pn. Jane was unable to provide support to the other science teachers. According to the minutes of one of the science meetings (S2:D11), one of the science teachers raised the problem of pupils who could not read. Pn. Jane did not attempt to provide any suggestion nor did she initiate any discussion of possible remedial action to overcome the problem. Instead, she requested all teachers who were teaching the weak classes to put in more effort to overcome the problems, without providing any specific suggestions of how to do it. She has attended two of the three orientation courses on the new primary science curriculum. As Head of Science in the school, Pn. Jane did not initiate any in-house training for the other science teachers who did not attend these course. She also did not disseminate the curriculum modules given out during the courses to the teachers. The curriculum modules which she received during the inserivce training were still in her possession.

6.4 Case Study Teacher (3) : Pn. Jane

6.4.1 Teacher's profile

Pn. Jane had twelve years of teaching experience in primary schools. She had taught a wide range of subjects including Bahasa Malaysia, Man and His Environment, Mathematics, Science, Moral Education and Physical Education. She disliked teaching Moral Education and Physical Education. This was her third year of teaching science since the introduction of science in primary four in 1995. Her specialisation during her pre-service teacher education was Bahasa Malaysia. At the time of this study, she was only teaching science, teaching a total of 24 lessons of science per week in 4A, 6A, 6B and 6C. Besides being the Head of Science in the school, she was also a teacher advisor for Red Crescent Society and Basketball Club.

Pn. Jane described her personal experience of learning science during her school days as satisfactory. She liked the idea of her teacher relating a new topic to the students' existing knowledge, thus making it easy for her to understand. She considered teacher explanation, questions and answers, students copying notes followed by tests as acceptable routines in science teaching. She admitted that she has never done any practical work in science during her school days as she only studied general science and not pure science. General Science students did not sit for any practical examinations while pure science students were required to sit for practical examinations. Therefore, teachers teaching General Science normally did not conduct practical sessions for their students. The following was her description of the science lessons she experienced.

> The teacher came into the class. I remember this quite clearly for secondary four and five [upper secondary]. I cannot remember what happened in secondary one [lower secondary]. The teacher made us understand, explained first, like usual. After that the teacher gave notes, we copied and discussed together. Sometimes, we had tests, questions and answers, group work, project. It is like normal.
>
> (S2:T1:I1:P1)

> It is OK. That is why I am interested. When the teacher introduced a new topic, he always related it to our existing knowledge. So it was easy to understand.
>
> (S2:T1:I1:P1)

Pn. Jane was anxious when she first taught science two years ago. Her anxiety diminished gradually with the availability of more reference books. At the time of this study, she described teaching science as challenging.

> Science is challenging. If the teacher is not used to teaching science, they are scared to teach science. The pupils may ask and we don't know the answer. At the beginning, I was scared also. I always read first before I went into the class. Since I have to teach, I have to search for it. It is good for me. I have learned a lot of things which I did not know before.
>
> (S2:T1:I5:P2)

Pn. Jane expressed displeasure in having to teach three primary six classes as teaching examination classes put a lot of pressure on her. She did not voice her problem to the authority concerned as she did not like to be seen as anti-authority.

> If possible, give me one or two classes of primary six only. It is too heavy to take three classes of primary six because they have UPSR exam. The pressure is too great. I do not mind teaching two classes of primary four, and two classes of primary six. It is more balanced. Right now, I have three classes of primary six and one class of primary four. I just teach. If I say anything, it may look like a protest. I try my best.
>
> (S2:T1:I1:P4)

6.4.2 Inside Pn. Jane's classroom

Pn. Jane had 50 'high ability' pupils in her 4A class. Pupils were seated in six groups of eight to nine pupils. The class timetable and the class cleaning duty roster were the prominent displays on the bulletin board while the rest of the bulletin board had yet to be utilised.

Pn. Jane taught 'Animal Reproduction' within a school week which consisted of five science lessons. She spent three lessons during her first session focusing on teaching the reproduction of animals which lay eggs and two lessons during her second session on teaching about animals which give birth. Her lessons are summarised in Table 6.1.

Pn. Jane did not use the activities suggested in the syllabus guide, textbook (Rahmat, Mamat, & Yusof, 1995a) or teachers' guide (Rahman, Mamat, & Yusof, 1995b). The activity suggested in both of them, involved pupils making scrap books on animal reproduction. Both the content and sequence of her observed lessons were based on the school-adopted textbook (Teo, 1995).

Pn. Jane centred on whole class teaching with little group work. The observed lessons involved teacher explanation, with questions interspersed between her explanation, followed by pupils copying notes into their exercise books and pupils doing the exercises from their workbooks. In her explanations, Pn. Jane attempted to relate the content taught to the real world. This was particularly conspicuous in the first session as the following examples show.

> Sometimes men are not responsible. They eat the turtle eggs and this is one of the reasons which can cause the animal to become extinct. In future, people will not be able to see turtles any more.
>
> It is important not to keep empty tins and tyres containing water, and to change water in the flower vase which is to prevent breeding of mosquitoes.
>
> Mosquitoes are also our enemies as they carry disease like dengue fever.
>
> You see the holes on vegetable leaves. This is because the caterpillars have eaten up the leaves.
>
> (S2:T1:O1:P3)

Throughout the lessons observed, Pn. Jane was trying to get the pupils to participate more actively in her lessons by asking them many questions, thus in her words, "encouraging them to think". However, most of the questions were low-level, convergent questions requiring short answers, and thus were not able to stimulate pupils' thinking or promote much inquiry.

Similar questions were asked each time Pn. Jane discussed the reproduction of the snakes, chickens, fish, crocodiles, frogs, birds, turtles and tortoises. The questions were: Where do they lay their eggs?; Do they look after the eggs?; Do they look after the young ones?; What do they do to the eggs? (S2:T1:O1:P2&3). Similar behaviour was observed in the second session when she questioned them on each of the animals

Table 6.1: Summary of Pn. Jane's lessons

Session 1 (Lessons 1, 2 & 3)	Pn. Jane explained to the pupils the importance of animals being able to reproduce - the animals would not become extinct, and that animals reproduce to increase their number within their species. She requested pupils to give her examples of animals which lay eggs which were then listed on the board. She brought to the attention of the pupils the case of whales which do not lay eggs as they are mammals. She asked a few questions on each of the animals listed, pertaining mainly on where they lay their eggs, the number of eggs laid, whether they look after their eggs, whether they look after the newly hatched ones. When Pn. Jane had finished discussing these animals, she asked pupils for more examples of animals which lay eggs. Turtles, tortoises and geese were added to the list. She discussed the turtle reproduction in detail by asking a number of questions. She also mentioned the irresponsibility of mankind to eat the turtle eggs, thus causing the animal to become endangered. This was followed by a very brief discussion on tortoise reproduction. Pn. Jane proceeded to explain the life cycle of mosquitoes by drawing sketches of the various stages on the board. She pointed out the danger of keeping empty tins and tyres which hold stagnant water and can become the breeding ground for mosquitoes. She also pointed out that certain mosquitoes can carry diseases such as dengue fever. She copied notes from a book on to the board. Pupils copied them into their exercise books. Pupils were getting restless and Pn. Jane had to call for their attention. Pn. Jane proceeded to explain that reptiles, amphibians, birds, fish, insects, molluscs, annelids, myriapods and arachnids lay eggs by using examples of frogs, butterflies, cockroaches, flies, snails and earthworms. She explained the life cycle of frogs with the help of sketches drawn for various stages of development. The life cycles of butterflies, cockroaches and flies were also explained with the help of sketches. The terms for various development stages of these animals such as nymph, larvae and pupa were introduced. She also told them that all insects must undergo larval and pupal stages before they become adult insects. Pn. Jane told the pupils about uniqueness of snails having both the male and female organs on the same animal. One pupil mentioned the term hermaphrodite twice but the teacher did not seem to take notice of it. Pupils were asked to complete the exercises in their workbook. Pn. Jane showed the chart on the developmental stages of the chicken egg and explained about the development of heart, legs, feathers, wings and beak.
Session 2 (Lessons 4 & 5)	Pn. Jane began the session by asking the pupils on how turtles reproduce. She wrote 'Animals that give birth' on the board. The pupils seemed to have known that mammals belong to the group of animals that give birth. Pn. Jane asked for examples of mammals. Pupils provided the answers: dogs, cats, rabbits, bats, whales, dolphins, goats, and humans. She wrote these examples on the board. Pn. Jane discussed the reproduction of human by asking questions like: How long is the gestation period?; How many young ones does the mother give birth to?. Similar questions were asked about the dog, cat, rabbit, bat and whale. Pupils were getting noisy and they were asked to keep quiet. Pn. Jane showed a chart of different animals: whale, dolphin, ostrich, peacock, camel, chicken, panda, penguin, cow, sea lion, swan, kangaroo, swallow, goat and other animals. She pointed to each animal in the chart and asked whether they give birth or lay eggs, the number of young ones or eggs, whether they take care of the young ones, how they take care of them and so on. Pn. Jane copied notes from a book on the board. Pupils copied them into their exercise books.

found in a chart: whether they give birth or lay eggs; how many eggs were laid or young ones given birth to; whether they take care of the young ones; and how they take care of them (S2:T1:O2:P3). Though all the questions could be said to be relevant to the topic taught, almost all of them were asked at level below the pupils' current level of functioning. As such, the lessons presented no challenge to this group of high ability pupils, and many of them appeared bored with the lessons. This, together with the monotonous nature of questions asked, could have been part of the reasons that these pupils appeared to be 'tuned out' of the lessons and they became restless, resulting in some discipline problem during her lessons. Pn. Jane admitted that this had happened quite often. Normally, she would have scolded and punished them. She attributed this to the seating arrangement of the pupils where pupils chose to sit with their friends in the same group. Though she suggested changing pupils' sitting positions as a possible solution, she had not done it so far as she felt that pupils' seating arrangement was the prerogative of the class teacher (S2:T1:I4:P2).

The school-adopted textbook and some charts were the main resources for Pn. Jane's lessons. She did not make use of specimens of various insects and other small animals which were readily available in the local environment. Pupils therefore did not have the opportunity to investigate about these animals and communicate their findings which were some of skills advocated in the curriculum. Pupils were also not made aware of other sources of information such as the use of the various encyclopaedia sets available in the school library and educational television programs shown over the national television network. This was because they were not provided the opportunity to look for information about various animals using these resources.

6.4.3 Pn. Jane's knowledge and understanding of science and science teaching

Teacher's understanding of the curriculum

Pn. Jane had attended two of the orientation courses on the new primary science curriculum. These courses did not appear to provide her with adequate understanding and knowledge to implement the curriculum effectively. According to her, she spent a lot of time and effort to try to understand the scientific skills in order to design appropriate practical tests for primary six pupils. Despite her effort, she commented that she was not confident whether she could integrate them into her lessons.

R: What is your understanding of the scientific skills?

Pn. Jane: The primary six practical exam tests the scientific skills. If I am not mistaken, there are eight of them. That I understand.

R: Do you understand how to integrate these skills into your lessons?

Pn. Jane: I dare not say that I understand very well. I can understand a little.

R: Are you confident enough to integrate them into your lessons?

Pn. Jane It is difficult to say. If you say I cannot understand, I can understand a little bit also. During the course, they did introduce a little bit also.

(S2:T1:I1:P4&5)

Pn. Jane's understanding of thinking skills was that of teacher asking questions and pupils having to think to provide the answers. She recognised the importance of thinking skills but did little to foster them. This might be due to her lack of understanding of what these skills were and how to foster such skills in her lessons.

R: What about thinking skills?

Pn. Jane: We ask them to think. They think and give us answer.

R: The new science curriculum hopes to integrate knowledge, scientific skills and thinking skills into the lesson. According to you, which is the most important?

Pn. Jane: For me, the thinking skills are important. If they do not want to think, they will not be interested to learn. For example, they have to think about how frogs reproduce, move and breathe.

(S2:T1:I1:P5)

Asked about what she understood by scientific attitudes and moral values, she said, "When they do group work, there is co-operation. They do not make noise" (S2:T1:I1:P5). It seems that for her, co-operation means working together in a group without noise. Pn. Jane considered both knowledge and skills as important since they were very much interrelated (S2:T1:I1:P5). She acknowledged that as her teaching style involved mainly teacher explanation, her lessons did not provide opportunity for integration of manipulative skills and scientific skills. This was reiterated in her lesson plans which contained knowledge-based objectives without any skill-related objectives.

R: We have talked about scientific skills, thinking skills, manipulative skills, scientific attitudes and moral values. How did you integrate any of these in your lessons?

> Pn. Jane: There were thinking skills. I asked them questions. They had to think before they could answer. I did not integrate any manipulative skills. I did not integrate scientific skills because I did a lot of explanation.
>
> (S2:T1:I4:P1)

Though Pn. Jane felt that the new science curriculum encouraged the pupils to do more investigation, this was not reflected in her lessons on 'Animal Reproduction'. She seemed to think that the teaching-learning strategies advocated in the new science curriculum were more suited to the clever pupils, and that the expository approach was more suitable for weak pupils (S2:T1:I1:P6). She had no understanding of terms like 'constructivist model of learning', 'hands-on' and 'minds-on' mentioned in the modules on science teaching-learning strategies.

Use of curriculum materials

Pn. Jane had in her possession curriculum materials such as the syllabus guide, the textbooks, the teachers' guide and the curriculum modules. However, she did not seem to see the relevance of these materials in the planning of her science lessons. She described the syllabus guide as being not very helpful as it contained limited activities. She only referred to the syllabus guide to copy the objectives into her lesson plans and as a guide to follow the sequence of topics to be taught (S2:T1:I1:P7). In one interview, when asked whether she would consider teaching plant reproduction before teaching animal reproduction, she was adamant about teaching according to the sequence as in the syllabus guide. She replied, " In the syllabus, animal reproduction is before the plant reproduction. We follow the sequence in the syllabus so that we do not miss out any topic" (S2:T1:I4:P5).

Pn. Jane indicated that she had included more content than was required in the curriculum. She considered the syllabus requirement of the content for the topic as inadequate, and therefore, had included content from the school-adopted textbook (S2:T1:I4:P1). Pn. Jane used the school-adopted textbook to provide the notes and exercises in her lessons. Throughout the lessons observed, she did not refer the pupils to their official textbook. She admitted to not using the curriculum modules with the exception of the module on management for science room which she was in charge of (S2:T1:I1:P5).

Intelligence and hard work as essential in pupils' learning

Pn. Jane believed that diligence, intelligence and interest were essential ingredients for learning. She stressed that pupils had to work hard in order to do well and good pupils were easy to teach as they were also hard working. According to her, pupils did not perform well in the assessment because they were lazy. Pn. Jane was of the opinion that the pupils were responsible for their own learning and that the teacher would not be able to do much without effort from the pupils.

> Pn. Jane: Sometimes the pupils are lazy especially Primary 6C pupils. Primary 6A is OK. If I ask them [6C] to do projects, their product is not satisfactory when compared to 6A where the products are very good. They [6A] try their best and do properly. Primary 6C pupils will not do their best - as long as they have something to pass up. That is possibly why their result is not very good. They all will pass. To get A is a bit difficult. May be they are lazy or other reasons.
>
> (S2:T1:I1:P1)
>
> R: Do you feel all the pupils can learn science?
>
> Pn. Jane: Their effort is important. If it is the weak class and they are lazy, it is no use even if the teacher teaches twenty four hours [a day].
>
> (S2:T1:I5:P2)
>
> Pn. Jane: It is easier to teach the good classes. If we ask them questions, they already know the answers. Sometimes I try to trap them by purposely saying something which is wrong. They will point out my mistakes. I purposely test their IQ. If it is the weak class, we can say anything, but there is no reaction. Their answers are also wrong. I prefer to teach good classes. They also finish their work fast, like primary 6A.
>
> (S2:T1:I1:P4)

Repetition and reinforcement help pupils' learning

Pn. Jane mentioned the need to use more activities to help the weak pupils understand. By activities, she was referring to giving more examples and asking more questions.

> R: Do you use the same method to teach the weak class and the good class?
>
> Pn. Jane: If it is a good class, it is easier to teach and it is more difficult to teach a weak class. For the weak class, I take a long time to teach a topic, and I have to give them more examples.
>
> R: Do you still use explanation?
>
> Pn. Jane: I use explanation. I use more examples. I will keep using more activities until they understand.
>
> R: What are the activities?
>
> Pn. Jane: I use more questions. If I do demonstration, I have to do more times. For a good class, I have to show only once.
>
> (S2:T1:I3:P5)

Pn. Jane emphasised the use of repetition and reinforcement to help the pupils of primary 6C to recapitulate content learnt in primary four and primary five. Though she did stress the importance of understanding over rote learning, most of the time she seemed to assess pupils' understanding by their ability to regurgitate factual knowledge.

R: Do you use the same approach to teach the good and the weak pupils?

Pn. Jane: Even like in 6B which is the good class, not all of them are clever. There are some pupils who do not know. When I teach, I always ask them. Like 6A, I just give points. Like 6C, I have to repeat those things that they have learnt in year 4 and year 5 because they are related. I have to do a lot of revision.

R: Does this help them to remember or to understand?

Pn. Jane: They have to understand before they can remember. If they do not understand and remember by rote only, if the questions are in slightly different form, they will not be able to answer. That is my opinion only.

(S2:T1:I5:P2)

Use of resources

Pn. Jane confessed that her lack of skills in using microscopes had prevented her from using them. Consequently, five new microscopes have been left in their boxes unopened and not used.

When I was in school, I have never used a microscope. I do not know how to use it. I am being frank here. Maybe there was no microscope in my school at that time. I have told the school inspector who came to inspect the school. They understood my position. During the course, we have not been exposed to the use of the equipment.

(S2:T1:I1:P2)

She admitted to not using the sets of science encyclopaedias in the school library and preferred to use the commercial books directly based on the curriculum. Charts seemed to be her favourite teaching aids, and she did not use other educational media, like television programs, for her lessons.

Teacher's understanding of science concepts

Pn. Jane had a fairly good understanding of most of the concepts taught. However, there were a few instances where she lacked understanding of some of the concepts. In one lesson, Pn. Jane drew five different stages for the life cycle of mosquitoes: egg, jentik-jentik, larva, pupa, adult mosquito.(S2:T1:O1:P3). 'Jentik-jentik' was a local name used to refer to the larval stage of mosquito and therefore should not have been counted as a separate stage. She also explained that all insects had to pass through the larval and pupal stages before they become adult insects (S2:T1:O1:P4). Actually, this applies only to those insects which have complete metamorphosis.

Insects like cockroaches and grasshoppers, which have incomplete metamorphosis , do not undergo these four stages. The eggs of these animals hatch into nymphs which resemble the parents except for the absence of wings and these grow into the adults.

Pn. Jane realised that it was not possible for a teacher to know everything about a topic and that the teacher could also learn with the children. However, she believed that it was necessary for teachers to have a wide knowledge to be able to make teaching more interesting. She expressed concern that she may eventually be put into the embarrassing position of appearing inept before the children if she did not know the answers. Therefore, she would avoid asking questions of which she was unsure of the answers. For example, in one of the observed lessons, she asked about the gestation period for human while ignoring that of other animals like dogs and cats. She also expressed her concern regarding parents complaining about teachers providing pupils with wrong answers.

> R: You asked about the gestation period for human. Why didn't you mention about the other animals?
>
> Pn. Jane: Because I do not know about the gestation periods for other animals like dogs and cats. I am not sure. So I do not want to tell. If I give the wrong answer, the pupils will tell that the answer is wrong.
>
> R: Many of your pupils told you that they have dogs and cats at home. Why didn't you ask them?
>
> Pn. Jane: Pupils may give different answers. For example, for cats, they will say three months, some will say five months.
>
> R: If you have known, ...
>
> Pn. Jane: If I know, I will tell them. Even though I am teaching science, I do not know everything.
>
> R: Do you think it is very important for the teacher to know this?
>
> Pn. Jane: It is important. If I read the information from the book, I know. Sometimes I forgot what I studied while I was in school. I learnt that when I was in secondary three.
>
> R: Do you think this type of information is of interest to the pupils?
>
> Pn. Jane: They are interested. But the problem is that the teacher is not sure. They will give many different answers. They will say the teacher does not know. If I try to find, I can find the answers. But I have a lot of work to concentrate on. Whatever I know, I let them know. I may need one whole week to find the answer.
>
> R: You would have liked to find all this information?
>
> Pn. Jane: Yes. It is a lot of work to look for information for different topics.
>
> R: Do you think that teachers need to have wide knowledge?
>
> Pn. Jane: Yes. (S2:T1:I4:P3&4)

In another instance in her lessons, when she asked the pupils for animals which lay the most eggs, they gave three different answers and she did not respond to these answers. In the stimulated-recall interview, she revealed that her reason for not responding was probably because she was unsure of the answer (S2:T1:I4:P3).

In the interview-about-instances, when asked whether she would let her pupils choose their own examples of objects, in order to name the materials of which the objects were made of, she was adamant that she would not because "they will give different types of objects. I do not know the answers myself" (S2:T1:I2:P5). On the observed lesson on flowers under plant reproduction, she obviously did not understand the relationship between flowers and seeds, and therefore did not explain the concept to the pupils.

> R: You talked about plants reproduce using seeds and you were teaching about flowers. Whay is the relationship between the flowers and the seeds?
>
> Pn. Jane: I was thinking about that. The book used that.
>
> R: Actually what you want to show is that seeds come from flowers. For flowering plants, flowers become seeds when pollinated and fertilised. Ovaries become fruits and ovules become seeds.
>
> (S2:T1:I4:P5)

Teacher's understanding of instructional strategies

Pn. Jane regarded teaching as knowing the content and introducing it to the pupils. She believed that teacher explanation was the most effective way to introduce the content to the pupils. According to her, she would introduce activities if there was extra time. She believed that activities could help pupils to understand and remember better. She also recognised that pupils were interested in doing activities and therefore could motivate them to learn. When asked whether she required help in content or teaching methods, she made it very clear that she preferred more help to increase her content knowledge.

> If the topic is easy to teach, and there are a lot of ideas to talk about, I am very interested to teach. If have to teach about topic like natural and synthetic materials which I am not sure and not confident, it will be difficult.
>
> (S2:T1:I2:P8)
>
> Explanation is important. If they watch a video and the teacher does not explain, they will not know. Explanation can help understanding.
>
> (S2:T1:I2:P7)
>
> Activities are also important so that the pupils can understand properly. They can remember better. If they do [carry out activities], they are interested to learn.
>
> (S2:T1:I2:P5)

Pn. Jane did not appear to be enthusiastic in trying out new activities in her lessons. The following conversation occurred while talking on the possibility of inviting speakers as one of the teaching strategies to be used in science lessons.

> R: Did you ever invite anybody to talk to your pupils?
>
> Pn. Jane: Never.
>
> R: Do you think it is possible?
>
> Pn. Jane: I do not know because I have not done it before. It is not easy to invite them unless they are willing.
>
> (S2:T1:I2:P6)

When asked about getting the pupils to do a project on observing the different phases of the moon over a month, she responded, "Are you sure they will really do it? I am not confident. They might do it one or two nights. They might be busy and forget about it" (S2:T1:I2:P6). She reacted similarly when the researcher suggested the possibility of getting the pupils to look for information from books. She reacted, "Do you think that it will have an effect or not? They might just play around" (S2:T1:I3:P4).

The conformity to the practice of other teachers in the school seemed to provide justification for some of her teaching practices, like spending more time on teacher explanations and questions, with little time spent on activities, and not using educational media.

> We have problems to finish the syllabus. We use a lot of time to teach and little time on activities. Other teachers also do that. We have to finish the topics for the exam.
>
> (S2:T1:I1:P7)
>
> Not only me. I think the other teachers also have not used them [referring to the use of the video recorder and TV in the resource room].
>
> (S2:T1:I2:P5)

Examinations as top priority

Like many teachers, ensuring pupils' good performance in their UPSR examination seemed to be of high priority in Pn. Jane's allocation of her time and energy. Therefore she spent more time and effort in matters which were seen as highly relevant to pupils' performance in UPSR examination. Her priority was with the primary six pupils over the primary four pupils as she bluntly expressed in one of the interviews, "This year, I concentrate on primary six. I do not concentrate on primary four. I ask the other primary four teachers to help out" (S2:T1:I1:P3). Pn. Jane also put in a lot of time and effort in designing the primary six practical evaluation (PEKA) (S2:T1:I4:P6). This practical evaluation which formed part of the national assessment for science, was school-based, and was generated by teachers within the school.

Pn. Jane believed that experiments would help pupils to answer structured questions in UPSR examination and she talked enthusiastically about wanting to do more experiments.

> Pn. Jane: I would like to do experiments whenever possible. Structured questions [from the sample UPSR examination] are about experiments.
>
> R: Do you feel that if the pupils do not do experiments, they will find it difficult to answer the questions?
>
> Pn. Jane: They are not used to it. They have to look at the diagrams and reason out.
>
> (S2:T1:I5:P3)

Professional support

Pn. Jane had no idea as to where or whom she could turn to for help when confronted with problems relating to science teaching. This is obvious from the following conversation:

> R: Do you feel you can get some help from the education department or the teacher activity centre?
>
> Pn. Jane: For what? Is there anything like that? Can we do that?
>
> R: So you have never contacted them?
>
> Pn. Jane: Never.
>
> R: When you do not have enough equipment, do you request from the school?
>
> Pn. Jane: Never.
>
> (S2:T1:I1:P3)

During an informal conversation, Pn. Jane brought up some problems related to the implementation of PEKA. The researcher, being relatively unfamiliar with PEKA, suggested that she could contact the officer in charge of the science curriculum in the Sabah State Education Department. She did and she was referred to one of the science resource teachers. She was grateful to the resource teacher who had agreed to meet up with the teachers in the school and clarify matters which they did not understand (S2:T1:I4:P6).

Coping with stress

Pn. Jane revealed that having to prepare 150 primary six pupils for the UPSR examination had put tremendous pressure on her. However, she tried to cope within her limits. For example, for PEKA, she tried to think of something that was easy for the pupils to do and easy for her to evaluate.

> I thought for weeks about what I should do because I am not used to it yet. I am not sure whether I can do it or not. For example, there are eight scientific skills. I have to think of what is easy for the pupils to do and also easy for me to evaluate. I do not want it to be difficult for me to evaluate. There are many pupils, 150 pupils. Even when I am at home, or sleeping, I will think of it. In school, I am busy and cannot think. ....
>
> (S2:T1:I4:P6)

The same principle applied in her planning of other teaching activities. Pn. Jane had asked her pupils to do projects such as making scrap books and posters which she regarded as easy. When asked whether she had asked her pupils to carry out projects like making a terrarium for keeping snails, she had not done so as she seemed to regard such type of projects as difficult.

> R: Did you give the primary four pupils projects to do so far this year?
>
> Pn. Jane: No. Last year, I asked them to do scrap books and posters.
>
> R: What about projects like asking them to make something to keep snails in?
>
> Pn. Jane: No. I only do the easy ones. Not the difficult ones.
>
> (S2:T1:I3:P2)

6.4.4 Summary

Pn. Jane regarded science teaching as the transmission of science knowledge from the teacher to the pupils. She therefore emphasised the importance of the effective science teacher to have a wide knowledge of science and preferred courses which emphasised content. She believed that teacher explanation was the most effective means to introduce such knowledge to the pupils. Games, projects, visits and experiments were not regarded as an integral part of learning. These were to be carried out only if there was more time. She did not see them as activities which could go hand in hand with teacher explanation to facilitate pupils' better understanding of science concepts.

Pn. Jane asked many questions interspersed between her explanation. Almost all her questions were low-level, convergent questions requiring short answers. Many of these questions were aimed at finding pupils' existing knowledge, and therefore did not command any challenge from the pupils or promote any inquiry from them.

Pn. Jane was concerned about appearing inept before her pupils which according to her could result in losing the respect of her pupils. Avoiding questions which she did not know the answers, not responding to the pupils' answers when she was not sure, and adhering content strictly to the book, were some of the strategies she adopted to safeguard herself from exposing her lack of science knowledge. The conformity to the practice of other teachers seemed to provide justification for her actions, such as not using educational media, and spending more time on teacher explanation and little time on activities. She also expressed her concern regarding parents complaining about teachers providing pupils with wrong answers. The Head Teacher's disapproval of noise in the class was given as a reason for not including activities which might cause noise. Trying to live up to the expectations of the pupils and their parents, the head teacher and the colleagues, seemed to be a major contributing factor in her much restricted teaching style.

Pn. Jane took a special interest in matters which were seen as highly relevant to the UPSR examination. Preparation for primary six science lessons took priority over those for primary four. Extra worksheets were prepared for primary six pupils and a lot of thought and effort went into designing the PEKA examination for these pupils. She showed much enthusiasm to want to do more experiments as she believed that experiments would help pupils in answering the structured questions in the UPSR examination.

Pn. Jane seemed to have acquired very little understanding of the curriculum requirements from the two five-day in-service courses she attended. She admitted that her expository style of teaching did not allow for the integration of scientific skills into her lessons. Eventually, some of the high ability pupils were seen to have become bored and restless. This had created some management problems in her lessons.

Pn. Jane did not consider the syllabus guide, the textbook, the teachers' guide and the curriculum modules to be helpful. She frequently referred to the school-adopted textbook which seemed to have enough content to meet her needs. Pn. Jane also under utilised the existing resources in the school and the local environment. She had not referred to the science encyclopaedias in the library. She had never used educational television in her lessons even though a television and a video cassette recorder were available in the school.

As Head of Science, Pn. Jane had been efficient in carrying out the administrative work required of her such as planning of science activities and conducting science meetings. She had also ensured the proper management of the science room. However, Pn. Jane was less efficient in ensuring the implementation of the activities. Her lack of knowledge of the role of collegial support as a way of professional development seemed to have limited her ability to create a conducive learning environment for the other science teachers where they can share their ideas and expertise. She did not initiate any in-house training for the science teachers who did not attend the relevant courses, nor did she disseminate the relevant materials to them.

Pn. Jane's teaching style might have been restricted due to her lack of knowledge and exposure to the various teaching strategies. She has not experienced science learning using an inquiry approach, therefore did not know how to do it and was certainly unsure of what would happen in the process and its effects. Pn. Jane's lack of knowledge and understanding about learning theories and learners' needs, put further constraints on her ability to use more diversified methods of science teaching. Repetition and reinforcement seemed to her to be the only way to help the weak pupils to learn science. She put the responsibility of learning wholly on the pupils, citing low intelligence and laziness as the main factors for pupils' failure in learning. She seemed to have little understanding of the role of teachers in facilitating pupils' learning. Consequently, her classroom teaching practice centred on whole class teaching, treating all pupils alike and ignoring pupils' individuality and interests.

The Malaysian primary science curriculum emphasises pupils' knowledge and understanding of scientific knowledge, pupils' development of scientific skills and thinking skills, and inculcation of values and attitudes. It promotes the use of inquiry to achieve these goals. It was obvious from the narratives of the lessons observed that Pn. Jane has not been able to implement the requirements of the curriculum. Transmission of science knowledge to the pupils seemed to be her major concern. She did not provide the pupils with opportunities for inquiry in her lessons. Teacher explanation interspersed with low-level questions and pupils copying notes were the routine of her lessons. Yet she seemed to think that she had done a reasonably good job. While she noted the need to expand her own subject content knowledge to be able to teach more effectively, she seemed unaware of her other inadequacies which included the lack of knowledge and understanding of the curriculum implications, a wider repertoire of instructional strategies, learning theories, and pupils as learners.

6.5 Case Study Teacher (4): Pn. Christina

6.5.1 Teacher's profile

Pn. Christina was the youngest teacher under study with nine years of teaching experience in primary schools. She studied General Science up to School Certificate level. Her specialised subjects during her teacher education were Bahasa Malaysia and Art. She had taught Mathematics, Bahasa Malaysia, Art, Man and His Environment and Science, and had expressed her dislike in teaching Mathematics, Bahasa Malaysia and Art. This was her third year of teaching science. At the time of the study, she was teaching science in 4D, 5C, 5D and 6E. She was also the class teacher of 5C. Her other duties included being a teacher advisor for Red Crescent Society, Science Club, and the Rounders. She was also one of the sports house teachers.

Pn. Christina described her frustrations and difficulties in learning science the expository way during her secondary school days.

> Science is difficult because there are many topics. We have to think one by one. It is not like Bahasa Malaysia where we hear it everyday. It is also confusing. ... Most of the time the teacher would write. The teacher gave us all the answers. We depended a lot on the teacher. The teacher always gave the answers.
>
> (S2:T2:I2:P1)

Pn. Christina also expressed her dissatisfaction with her science learning in the subject 'Man and His Environment' during her pre-service teacher training program. Her science learning experience gained in this program did not offer her much help in teaching science because it did not expose her to the various strategies of teaching science. She and the other teacher trainees were left to struggle on their own with little guidance from the lecturer.

> R: What was your experience of learning 'Man and His Environment' in teacher training course?
>
> Pn. Christina: I am not complaining about the lecturer. Often we were on our own. The lecturer entered the class, gave us the topic and asked us to discuss and refer to books. We were then asked to present our work in front of the class. After the presentation, we had the questions and answers session. The lecturer would just sit at the back and watch. When we asked the lecturer, we were told to look for reference books. This is what we did all the time.
>
> (S2:T2:I2:P1)

Pn. Christina described the five day in-service science course she attended recently as too short and there was too much theory with very few practical activities. She preferred courses which have a lot of practicals like how to teach in the class, preferably looking at some good lessons taught (S2:T2:I2:P1&2). She realised her incompetence in science knowledge and wanted more opportunities to learn content relevant to the primary science curriculum. She considered reading up on her own to gain this knowledge as not feasible (S2:T2:I4:P7).

6.5.2 Inside Pn. Christina's classroom

Pn. Christina was teaching science to 50 weak pupils of class 4D. Just like all other primary four classes, her pupils were seated in six groups with 8-9 pupils in each group. The class timetable and the class cleaning duty roster were displayed on the bulletin board while the rest of the bulletin board had yet to be utilised.

Pn. Christina spent a total of seven lessons on 'Animal Reproduction'. The first double-period session was spent on turtle reproduction, followed by the second three-period session on the reproduction of various insects. The reproduction of mammals was taught in the third double-period session. Her lessons are summarised in Table 6.2.

The scope and sequence of her lessons were based on the school-adopted textbook. All examples that she used during her lessons were from this book. The main activity during Pn. Christina's lessons centred on pupils drawing pictures of animals. In the first session, pupils spent nearly half of the session (26 minutes) to draw the four pictures on turtle reproduction. In the second session, they spent almost an hour (58 minutes) to complete a chart on the life cycle of one insect by copying the pictures from their reference books. Upon completion of the drawing activity, the pupils were asked to present their work in front of the class. Pn. Christina did not provide any guidelines as to what was to be presented. Moreover, the reference books contained only pictures of life cycles of various insects with no accompanying textual explanation. Pn. Christina did not explain the life cycles of these insects to the pupils, and no other reference materials were provided for them. Consequently, when the first group of pupils were asked to present their work to the class, two pupils held the chart and another pupil read out the different stages of development of the insects as this was the only information they could obtain from their books. Other groups of pupils presented their work in exactly the same manner.

Table 6.2: Summary of Pn. Christina's Lessons

Session 1 (Lessons 1 & 2)	Pn. Christina began the lesson by telling the pupils that animals reproduce either by giving birth or laying eggs. She asked for examples of animals that lay eggs. She proceeded by recapitulating pupils' knowledge on different groups of animals: mammals, birds, reptiles, amphibians, fish, molluscs, insects, myriapods and arachnids. She asked pupils for examples of reptiles. Pn. Christina asked pupils questions on turtle reproduction based on a series of pictures on a chart. Pupils were then asked to copy the series of pictures on turtle reproduction from their book into their exercise books. When they had finished drawing, Pn. Christina requested some pupils to come to the front of the class to describe how turtles reproduce.
Session 2 (Lessons 3, 4 & 5)	Pn. Christina began the session by reviewing content from the previous session on turtle reproduction. Pn. Christina asked pupils for examples of insects and the pupils gave the answers as cockroaches, mosquitoes, ants and spiders (a wrong answer not corrected by the teacher). She explained that some of the newly hatched insects do not resemble their mothers while those that resemble their mothers are called nymphs. She asked for examples of both types and the pupils read out the examples from their books. Pupils (6 groups) were assigned to complete a chart on the life cycle of the insect allocated to them by the teacher. The life cycles of five insects were found in the book: cockroaches, grasshoppers, butterflies, mosquitoes and houseflies. Since there were six groups of pupils, two groups were asked to draw the life cycle of houseflies. Three groups of pupils presented their work in front of the class by showing their charts reading out the terms for the different stages in the life cycles of the insects.
Session 3 (Lessons 6&7)	Pn. Christina asked pupils for examples of animals that lay eggs. Pn. Christina explained about reproduction of animals such as whales and dolphins which give birth, take care of their young ones by feeding them with milk and protecting them from enemies. She gave examples of how their (the pupils') parents take care of them especially when they were young. She asked for examples of land animals that give birth and pupils gave the answers as tigers, monkeys, cats and dogs. She then asked the pupils as to the numbers of offspring by each of these animals. She also discussed the number of babies born at one time by humans. Pn. Christina copied two questions on the boards and the pupils were asked to answer them in their exercise books. The questions were: (1) Give four examples of land animals that give birth, and (2) Give two examples of sea animals that give birth. Pupils were also asked to complete the exercises in their workbooks.

Pn. Christina asked a lot of questions in her science lessons, almost all of which were at the factual level. Some examples were: What does the turtle use to fill up the hole?; Where does the turtle go after it fills up the hole?; Does it wait for the eggs to hatch?; What happens to the turtle eggs?; Is the mother turtle near the eggs?; Where has the mother turtle gone?; Where do the baby turtles go?; How many eggs does a turtle lay? It might be obvious for a person with science background knowledge to understand what she was trying to get at through the series of questions. But, it would be difficult for weak primary four pupils in her science lessons to grasp these concepts without teacher's deliberate effort to emphasise the concepts. She did not provide any review or summary of the answers to the questions she asked.

Pn. Christina recognised that pupils had prior knowledge related to animal reproduction as some pupils might have seen their dogs or cats giving birth. However, she only asked them about the number of offspring and did not question them further on the conditions of the young and the care provided by the parents.

6.5.3 Pn. Christina's knowledge and understanding of science and science teaching

Teacher's understanding of science concepts

Pn. Christina did not show clear understanding of several science concepts both during the observed lessons and the interviews. She told her pupils that the difference between moths and butterflies was that moths were bigger than butterflies (S2:T2:O2:P2). She explained to her pupils about whales being an example of fish which do not lay eggs but give birth (S2:T2:O3:P1). She did not correct the pupil's answer when the pupil named spiders as an example of an insect (S2:T2:O2:P1). In the extra lesson observed on measurement of temperature, Pn. Christina told the pupils that alcohol was the red-coloured liquid used in the thermometer for the range of -10 degree Celsius to 110 degree Celsius (S2:T2:O4:P1). In one interview, when asked about her understanding of 'volume', and to give some examples of elastic materials, she admitted having to look up in the book (S2:T2:I4:P3). She made no differentiation between objects and materials (S2:T2:I4:P3).

Teacher's understanding of the curriculum

Pn. Christina seemed to have little understanding of the various aspects emphasised in the new primary science curriculum, especially those related to thinking skills, scientific skills, moral values and scientific attitudes although she seemed to be familiar with manipulative skills. The following conversation reveals her lack of understanding of these terms.

> R: What is the requirement of the new science curriculum concerning the teaching strategies?
>
> Pn. Christina: Thinking skills so that pupils know about science.
>
> R: Can you give me some examples of thinking skills?
>
> Pn. Christina: They must think about life and the environment. They should not be restricted to the book. They should relate it to the environment.

R: The new science curriculum emphasises on content, scientific skills, thinking skills, manipulative skills, scientific attitudes and moral values. Which of these do you understand?

Pn. Christina: I understand manipulative skills. The rest is not clear to me.

R: What do you understand about manipulative skills?

Pn. Christina: They know how to use and store science equipment properly.

R: What do you understand by the content?

Pn. Christina: That is about the objectives.

R: What about the scientific skills?

Pn. Christina: I can understand but I find it difficult to explain.

R: Give me some examples of these. Eight of them are to be assessed in the practical exam.

Pn. Christina: Observe, classify, operation (define operationally), time (relationship between time and space). I am thinking of the easy ones first.

Researcher showed her the list of these skills.

R: Which of these are clear to you?

Pn. Christina: Observation and classification. I am not clear on the others.

R: What do you understand about the thinking skills?

Pn. Christina: I am not sure.

(Researcher showed her the list of creative and critical thinking skills stated in the curriculum module on thinking skills).

R: Have you heard of these terms?

Pn. Christina: They did mention them occasionally during the course. They did not discuss them in detail because that has been done in the primary four course.

R: What about moral values? We are supposed to incorporate these values in all subjects. How many values are there?

There was no response from the teacher.

(S2:T2:I2:P5&6)

In all the three lesson plans on animals reproduction, Pn. Christina has written ‘collecting data’ and ‘drawing’ as the two scientific skills to be acquired by the pupils. These two terms were repeatedly written as scientific skills in lesson plans for other units.

Pn. Christina understood that the new science curriculum encouraged more practicals for the pupils and the role of teacher as the guide to the pupils, guiding them to do projects and experiments. She considered that strategies like experiments, discussions, projects and simulations as suggested in the curriculum were ideal but not realistic. She argued that such strategies put a high demand on resources, teachers' time, and teachers' expertise (S2:T2:I2:P6).

Pn. Christina had not heard of terms like constructivist model of learning, hands-on and minds-on, inquiry approach, and guided discovery, as advocated in the curriculum documents (S2:T2:I2:P6).

Coping with a new subject and weak pupils with little collegial support

Pn. Christina faced problems teaching the weak classes where many of the pupils came from lower socio-economic families. Many of the pupils did not have the work books and the reference books. She had tried punishing the pupils to get them to buy these books but it did not work (S2:T2:I2:P3). Pn. Christina expressed her frustrations in having to learn to cope with teaching a new subject and to handle weak pupils at the same time. She was teaching science in four weak classes.

Pn. Christina was unable to solve these problems on her own, nor did she get any support from her colleagues to overcome them. During one of the science meetings, she raised the problem of pupils not having the proper books during a science meeting and did not receive any feedback so far. In another science meeting, she raised the problem of pupils not being able to read, resulting in them being unable to answer the questions during the tests or examinations. She was asking for some ideas on how to overcome this problem. While the Head of Science requested the teachers teaching the weak classes to increase their effort to overcome the problems ~~such as those put~~ forward, no concrete suggestions were offered. The problems persisted and this led to her feeling powerless, hopeless, helpless and stressed.

Pn. Christina often sought help from Pn. Fatimah who was also a participant teacher in this study. Pn. Christina did not turn to the other science teachers for ideas and advice concerning science teaching as she felt that they were reluctant to help her.

> R: Where did you get this idea of asking pupils to draw charts on the life cycles of various insects?
>
> Pn. Christina: I asked Pn. Fatimah.
>
> R: Do you always ask for ideas from other teachers?
>
> Pn. Christina: I always ask for help from Pn. Fatimah. She always cooperates. She does not ask me why I ask. Some other teachers asked why I asked. I do not like it.
>
> (S2:T2:I1:P2)

Teacher's low expectation of pupils

Pn. Christina seemed to perceive her pupils as 'problem kids' who were unmotivated and unable to perform even simple task like looking at the moon and drawing the shape of the moon every night over a period of a month. The following conversation occurred during the interview-about-instances concerning the feasibility of asking the pupils to carry out a project on the different phases of the moon.

> R; Pupils carry out a project on different phases of the moon. This means about one month before the teacher teaches the topic, teacher asks them to look at the moon every night at a certain time. They have to draw and record. It can be individual or group work. When we teach the topic, they can present what they have done. What is your opinion about this approach?
>
> Pn. Christina: More interesting. They themselves have to be diligent.
>
> R: Can your pupils do this?
>
> Pn. Christina: My pupils - it is hard to say.
>
> R: Is it difficult for them to see, draw, note the date and time?
>
> Pn. Christina: It is difficult for some of them. They do not even bring their books.
>
> R: Is it because they cannot do or because they do not want to do?
>
> Pn. Christina: Some cannot do and some do not want to do.
>
> R: You mean they cannot observe and draw?
>
> Pn. Christina: If it is drawing only, it may be possible. Some do not know how to spell. Some do not know anything. If you ask them, they just keep quite only.
>
> (S2:T2:I4:P5)

Pn. Christina described drawing and acting as two activities which her pupils enjoyed, and that she would engage them in these activities whenever she realised that they felt bored. A glance through pupils' exercise books revealed that the pupils had been drawing pictures of animals and plants since the beginning of the year. On the unit 'Physical characteristics of animals', pupils drew pictures of fish, bird, cat, prawn, cockroach, snail, rabbit and snake. On classification of animals according to their mode of nutrition, pupils drew pictures of two carnivores, two herbivores and two omnivores. They also drew pictures of animals according to their habitats.

Pn. Christina did not mention how these drawing activities could benefit the pupils in terms of their science learning. She seemed to be unable to get the pupils interested in her explanation. According to her, the pupils seemed to enjoy drawing and colouring rather than listening to her explanations and doing exercises. Therefore, she deemed it fit to occupy them with activities which they enjoyed even if these activities did not contribute much to their learning. The comfort level for her pupils meant she had fewer behavioural problems, which was likely the motivation for engaging these pupils rather than science learning.

> R: You asked them to copy diagrams of the turtles from their reference book. Why did you ask them to draw?
>
> Pn. Christina: They are more interested with the drawing. If we explain only and give them exercise to do, they feel bored. They enjoy drawing and colouring while chatting with their friends.
>
> R: Do you always ask them to draw?
>
> Pn. Christina: When I see that they are bored and there is some more time, I will ask them to draw.
>
> (S2:T2:I1:P1)

Teacher's conceptions of instructional strategies

Pn. Christina believed that the 'correct' way of teaching science required expensive equipment. She referred to the example of using living specimens of birds which were expensive but which pupils would definitely find more interesting rather than looking at pictures of birds (S2:T2:I2:P3&4).

When asked about using animals like cockroaches, grasshoppers and tadpoles, she felt very few pupils would bring them. She would not take the pupils to the field to look for them as it was difficult to control them once they were outside the classroom. Foreseeing the problems prevented her from taking any action, and she would always up using direct instructional strategy to teach. This attitude was also apparent when asked on the use of audio-visual media in her lessons.

> I have not used video before. For TV, we have to refer to the teacher in charge of the resource centre. We have to look for the timetable. Sometimes the time does not fit in. Last year, we had the timetable for educational TV. Now the teacher in charge is new. I am not sure whether there is educational TV program.
>
> (S2:T2:I2:P4)

> One of the reasons is that I never think of using it [education TV] and also it is difficult to obtain the materials. For the educational TV, I do not know the timetable for the educational TV. Previously, they used to provide the time table. I also did not use it because I did not think of using it.
>
> (S2:T2:I3:P6)

As a result, she has never used any television program, videotapes or slides in her teaching. Even when charts, videotapes, slides and slide projector were provided for the teacher to use, she made no attempt to use them. The researcher borrowed these equipment and materials from the education department resource centre and left them for the teachers in case they would like to use them in their lessons.

> R: I gave you two videotapes on animal reproduction. Did you look through them? Are they suitable?
>
> Pn. Christina: The video recorder at home was spoilt. I did not watch the videotapes in the school. I wanted to view them with Pn. Fatimah. She asked me to wait. I tried to find a suitable time so that we could watch them together and discuss. We did not have much free time together. There was always something to do.
>
> R: Does that mean that even if there are tapes given to you, there would still be problems for you to show them to your pupils?
>
> Pn. Christina: It depends on the situation. There is no black and white about the use of the video recorder from the teacher in charge of the resource centre. We did not ask either.
>
> (S2:T2:I4:P5)

When asked about using resources like invited speakers in science teaching, she talked of the possible problems.

> It may be a bit difficult. It depends on the cooperation, time, relationship, whether we know them or not. It is a bit difficult.
>
> (S2:T2:I3:P6)
>
> I have not done it before. It depends on the situation. For example, when I am teaching the topic, if the person is free at that time, then there is no problem. If the time is not convenient for the speaker, then possibly there is problem. The person has to be willing. We cannot force them.
>
> (S2:T2:I4:P5)

Fear of losing control of the pupils and pupils' safety seemed to have been prevented Pn. Christina from taking the pupils for outdoor activities such as field work and visits. She expressed her concerns about losing control of pupils in carrying out these outdoor activities. She based this on her experience of bringing pupils out for art lessons and was worried about the pupils getting out of control and someone in authority hearing the noise.

> It [outdoor activities for art lessons] is easier. But still I did not do it. In our school, we must be able to control our pupils so that they do not make noise or run about. If I take them out and I tell them to do this and that, there will be some pupils who will run here and there. ..... For drawing lessons, they will concentrate. If for science lessons, we show them this and that, they will run here and there.
>
> (S2:T2:I3:P3)

> One of the problems for visits is pupil control. For visits outside the school, it is also the responsibility. If the pupils get hurt, the teacher will be made responsible despite the permission from the parents. We do not feel comfortable because we will be questioned if any unfortunate incidence occurs.
>
> (S2:T2:I3:P3)

Teacher's competence in the use of science equipment

Pn. Christina admitted her incompetence in the use of laboratory equipment like microscopes and Bunsen burners. Her incompetence in using the equipment prevented her allowing her pupils to use them. She commented, "I do not know how to use the burner. I have not been shown how to use it. I do not dare to use it" (S2:T2:I2:P9).

Pn. Christina realised that one of the possible causes for the high reading for the temperature of the ice was due to the pupils taking the thermometer out of the ice to read the temperature. However, she did not realise the problem of measuring the temperature of ice by using ice cubes. By using big cubes of ice, the bulb of the thermometer is in the air space between the ice cubes and therefore does not accurately measure the temperature of the ice. This could have been achieved by breaking the ice into smaller pieces and putting them in a filter funnel to drain out the water to ensure that the bulb of the thermometer is immersed in ice and therefore more accurate reading of the temperature of ice could be obtained.

6.5.4 Summary

Pn. Christina experienced frustrations and dissatisfaction in her science learning, both during the school days, and in the pre-service teacher education program. Her science learning experience in pre-service teacher education had failed to equip her with the necessary science content knowledge and the pedagogical knowledge to enable her to teach primary science effectively. The in-service course she attended did not seem to offer her much help. She had not experienced models of science teaching-learning based on inquiry and problem solving approaches.

Pn. Christina was even more frustrated when she was assigned to teach science in four weak classes. Her expository approach of science teaching seemed to be inappropriate for the weak pupils as they seemed to be not interested in her explanation. She received little support from her colleagues or the school administration, and did not know of ways to motivate these pupils. Eventually, she found some comfort in taking advice from Pn. Fatimah whom she regarded as a mentor. As she realised that her pupils enjoyed drawing and colouring, the main activities of her observed lessons were centred on pupils drawing pictures of animals.

6.6 Case Study Teacher (5): Pn.Fatimah

6.6.1 Teacher's Profile

Pn.Fatimah had 22 years of teaching experience in primary school. Human and Social Biology was the only science subject she studied in her secondary education. Before the implementation of the new primary science curriculum, she taught Man and His Environment. At the time of this study, she was teaching science in 4B and 4C, and Local Studies in 5D, 6C and 6D. She was the Head of Local Studies in the school. Her other duties in school included teacher advisors for the Brownies, Rounders, and swimming Club. She was also one of the sports house teachers.

Pn. Fatimah had attended the five day in-service course for teachers who were teaching the primary science curriculum. She felt the need to attend more similar courses. She said, "I am still very vague about the whole thing, and I am still not sure" (S2:T3:I1:P5).

6.6.2 Inside Pn. Fatimah's classroom

Pn. Fatimah taught science to 50 'slightly above average' girls of Primary 4B. Pn. Fatimah did not use the activities suggested in the syllabus guide or the teachers' guide nor did she use the pupils' textbook in her lessons. Like Pn. Jane and Pn. Christina, she followed closely the content and sequence of the unit found in the school-adopted textbook.

Pn. Fatimah spent a total of eight lessons on teaching 'Animal reproduction'. The first double-period session was used to teach turtle reproduction. The second three-period session was used to teach reproduction of frogs and insects. The reproduction of mammals was dealt with in the final three-period session. A summary of her lessons are summarised in Table 6.3.

Pn. Fatimah's lessons were similar to those of Pn. Christina. This was no surprise as Pn. Christina had mentioned that she often sought advice from Pn. Fatimah as how to teach a certain topic. In all the three sessions observed, pupils were preoccupied with drawing and colouring animals. In the first session, pupils spent 26 minutes copying a series of four pictures relating to turtles reproduction from their reference books in a series of four pictures relating to turtles reproduction from their reference books in their exercise books. In the second session, pupils spent 56 minutes on drawing charts of the life cycles of various insects and the frog. Here, pupils were divided into six groups, and each group produced a chart on the life cycle of one of the animals assigned to them. All the pupils copied the diagrams from their reference books. In the final session, pupils spent 35 minutes in drawing an animal that gives birth and an animal that lays eggs.

Table 6.3: Summary of Pn. Fatimah's lessons

Session 1 (Lessons 1 & 2)	Pn. Fatimah asked the pupils the two ways animals reproduce. Pupils were asked to give examples of animals that give birth. When she asked for examples which were less commonly seen, one pupil gave the examples of bats. Pn. Fatimah stressed that a bat is a mammal and a bird. She then asked for examples of animals that give birth but live in the sea, examples of reptiles, and an example of a reptile that lives in water and lays eggs on land. Pn. Fatimah explained about turtle reproduction by asking a number of questions. She then showed a chart containing a few pictures on turtle reproduction and asked similar questions. She then referred the pupils to the pictures on turtle reproduction in the textbook. Pupils read out the information given for each picture. She then asked the pupils to copy the pictures on turtle reproduction into their exercise books. The pupils were instructed to bring the materials such as gum, scissors, colour pencils, and manila cards required for making charts in the coming science lesson.
Session 2 (Lessons 3, 4 & 5)	Pn. Fatimah introduced the pupils to the reproduction of frogs by asking a number of questions: Who can give me an example of an amphibian?; Do frog eggs hatch into mature frogs?; What does a frog egg hatch into?; What does a frog egg look like? Where does the frog lay the eggs?; Why do the eggs stick together?. She then asked one pupil to draw frog eggs on the board. She added a black dot on each egg telling the pupils that there was a black dot on the egg. Pn. Fatimah showed a chart on the reproduction of frog, and explained, "The eggs stick together so that they are not easily disturbed by the enemies. Just like us. There are some of us who do not like to eat jelly because it is sticky. The enemy of frog eggs may not like it too. A frog egg has the black dot on it and that is why the skin of frog has black dots on the body. That is how the frog reproduces." This was followed by more questions. Pn. Fatimah moved on to explain the life cycle of an insect using the examples of a cockroach. A number of questions were asked. She compared the baby cockroach with the human baby which resembled the mother. The term nymph was introduced to describe the baby cockroach. Pn. Fatimah repeated the explanation for the life cycle of cockroaches. She continued with the explanation of the life cycles of other insects like butterflies, mosquitoes and grasshoppers by asking numerous questions. She requested examples of insects which are in the same category as the cockroach. Pupils (6 groups) were was assigned to complete a chart on one of the animals - frog, cockroach, grasshopper, butterfly, mosquito or fly. At the end of the lesson, each group presented their work. Three pupils of the first group came to the front. Two pupils held the chart and the third pupil read out the title of the chart and the stages of development of the animal concerned. The other groups followed.

(continued)

Table 6.3: Summary of Pn. Fatimah's lessons (continued from p.176)

Session 3 (Lessons 6, 7&8)	Pn. Fatimah told the pupils that they have already learnt about the reproduction of reptiles, amphibians and insects and that they were going to study about animals which give birth, that is, the mammals. Pn. Fatimah asked the pupils to think of the difference between eggs-laying animals and animals that give birth. When one pupil answered that eggs laying animals do not look after the young ones, Pn. Fatimah asked further questions to make them realise that not all eggs laying animals do not look after their young ones, and that there are eggs laying animals which do look after the young ones. Pn. Fatimah asked the pupils about the characteristics of mammals. Pupils gave answers such as: Mammals eat other animals; Mammals give birth: Mammals feed their young ones with milk; Mammals live on land; Mammals have fur; Mammals are warm-blooded; Mammals give birth to their young ones alive. She summed up these characteristics. Pn. Fatimah then asked the pupils why humans are considered as mammals. She went on to ask them about human reproduction, for example, the gestation period of the mother, the number of babies delivered at one time, and care of the baby. She summed up, "Prepare food, give them milk, bring to the doctor when the baby is sick, educate them. When the young ones become independent and can find their own food, only then the mother does not look after them any more." Pn. Fatimah brought the pupils to examples of mammals like whales and dolphins that live in water, and proceeded to talk about mammals that live on land. She asked about the gestation period of the monkey, and brought their attention to kangaroos which carry their babies in their pouches. She also asked the pupils about how dogs and cats protect their young ones. The pupils were asked to complete the exercises on pages 36 and 37 of their workbook, after which they exchanged their workbooks among themselves to check the answers. Pn. Fatimah wrote the work to be done on the board: Name one animal that gives birth and one animal that lays eggs and draw the diagrams for each of the animals together with their young ones. 35 minutes was spent on this activity. During this time, Pn. Fatimah walked around the class checking on pupils' previous work.

During the drawing sessions, Pn. Fatimah did not provide opportunities for pupils to be cognitively engaged. She did not plan other instructional activities to compliment the drawing activities. The drawing activities ended the lessons in the first session and the third session. However, in the second session, pupils from each group were selected to present their work. For all the groups, two pupils held the chart and another pupil read out the various developmental stages of the life cycle of the animal. The presentation of the six groups took six minutes which amounted to a minute for each group. As mentioned earlier, the textbook used by the pupils contained only diagrams of the life cycles of these animals with no accompanying textual explanation. Though Pn. Fatimah had briefly explained on the life cycle of each of the animals, the pupils were uncertain as what to present, as the teacher did not provide any guidelines on the presentation. As the first group of pupils decided to read out the developmental stages of the animals, other groups seemed to follow the same style in their presentation. With proper planning and guidance from the teacher, presentation of pupils' work could have provided a rich environment for them to develop their communication skills. However, in this case, pupils in the observed lessons were deprived of these opportunities.

Besides drawing, teacher explanation interspersed with questions was the main instructional activity Pn. Fatimah used in her lessons. She seemed to be rushing through her lessons. For example, in the second session, she spent twenty minutes to explain the life cycles of six animals. She did not provide time for summarising the concepts learnt and checking for pupils' understanding of these concepts. She also did not relate the relevance of the content of the lessons to the pupils' daily lives.

Pn. Fatimah provided little or no opportunity for pupils to explain their reasoning or to reflect upon their ideas. The following dialogue was taken from one of her lessons.

> Pn. Fatimah: Birds look after their young ones. Which birds look for food for the young ones - the males or the females?
>
> (There were both types of answers. 16 pupils answered 'male' while the rest answered 'female').
>
> Pn. Fatimah: For those who say that the male birds look for food, can you tell me why?"
>
> P(i): The male looks for food while the female has to look after the young ones.
>
> Pn. Fatimah: Any other answers? (No wait time).
>
> Pn. Fatimah: Actually the female looks for food while the male stays near the nest to take care of the young ones. Why is that the male birds stay?
>
> P(i): so that the young ones will not be attacked by the enemies.
>
> (S2:T3:O3:P1)

In this case, only one pupil was asked to give her view of the possible reason for such behaviour. Moreover, as this answer contradicted the teacher's intended answer, Pn. Fatimah provided her answer which was "The female birds look for food while the male birds stay near the nest to take care of the young ones". Though 16 pupils indicated that the male birds looked for food for the young ones, not a single pupil questioned the teacher's answer, which was different from theirs. Pn. Fatimah did not request possible reasons for such behaviour of the birds nor did she seek the pupils' views on this matter. Actually, there are species of birds where the males look for food and the females look after the young ones.

Pn. Fatimah used some commercial charts of animals to help her in her explanation. She did not use any other resources in the teaching of animal reproduction. She did not attempt to bring any specimen for her lessons nor did she ask the pupils to bring them (S2:T3:I4:P4). Specimens of animals such as insects and other small animals which were readily available in the local environment, could have provided valuable resources for this unit. A number of books including a few sets of encyclopaedias containing information about animal reproduction were available from the school library but were not used. Pn. Fatimah did not use the slides and video cassettes provided by the researcher. This resulted in missed opportunities for the development of a wide range of skills such as observation, comparison and communication. Activities such as observing the males and females of various animals, observing various types of eggs, looking for the differences and similarities, and communicating the findings could have been easily incorporated into the lessons. Pupils could have also learnt the manipulative skills of using the hand lens to observe the various parts of the animals more closely.

Pn. Fatimah recognised that pupils have prior knowledge related to animal reproduction. Just like the other four case study teachers, she only questioned them on the number of newly born while no other information was elicited from the pupils.

Pn. Fatimah used a lot of questions in between her explanation. Almost all questions were at the factual level: Where do the tadpoles live?; How do tadpoles breathe?; How long does it take for the frog eggs to hatch into tadpoles? Pn. Fatimah treated each individual pupil response as either all right or all wrong. She did not attempt to connect the discussion to the pupils' own experiences and building up concepts from there. On one occasion, when the teacher asked for the characteristics of the mammals, one of the pupils answered "Mammals eat other animals.". To this, she responded with a curt, "We are not discussing types of animals like carnivore or omnivore. We are discussing animals in the mammals group" (S2:T3:O3:P2). There were occasions when she asked the pupils to look for the answers but she never referred to them again in the following lesson. One of the questions was: "How long does it take for the frog eggs to hatch into tadpoles?" (S2:T3:O2:P2).

Pn. Fatimah seemed to restrict the type of responses provided by the pupils. Instead of encouraging pupils to express their ideas in their own words, they were expected to respond with the precise wordings found in the book.

> Pn. Fatimah: Why do the turtles lay the eggs at night and not during day time?
>
> P(i): They do not want to be disturbed by human.

Pn. Fatimah: Any other answer?

P(i): They want to be safe from the disturbance of birds and other preys.

Pn. Fatimah: Correct. It is because they want to be safe from the disturbance of birds and other preys. (The reference book contained the sentence: 'Turtle eggs hatch at night so that they are safe from the disturbance of birds and other preys" (Teo, 1995, p.61).

(S2:T3:O1:P4)

When Pn. Fatimah asked the pupils as to the number of eggs laid by a turtle at one time, she rejected the answer 80-100 given by one of the pupils. She regarded 150-200 found in the book as the correct answer. In the following excerpt, she explained why she regarded the information provided by textbook as correct.

R: When you asked how many eggs are laid by the turtle, some pupils gave the answer as 80 to 100. Do you think it is wrong?

Pn. Fatimah: I have not seen it myself. I read from the book. The minimum is 150 up to 200.

R: The book mentions from 100 to 200. Is the number very important?

Pn. Fatimah: Yes, it is from 100. I think the pupils should know.

R: Do you think that for different types of turtles, the number of eggs might be different?

Pn. Fatimah: The experts must have studied about this and wrote that in the book. We have checked through three books which give the same figure. When I set the exam question, I wantedto know. Pn. Jane queried about that. Since all the three books give the same figure, we agree. The people who study know the minimum.

R: Do you consider the information given in the book as correct?

Pn. Fatimah: I think it is correct. It is not one person who did the study. Many people studied.

(S2:T3:I4:P2)

6.6.3 Pn. Fatimah's knowledge and understanding of science and science teaching

Teacher's understanding of science concepts

Pn. Fatimah lacked adequate understanding of a number of science concepts taught in the primary science curriculum. She was confused as to whether bats are mammals or birds, and whether whales are fish or mammals. In one of the interviews, she admitted that she was confused and had constructed her own understanding of a bat being both a bird and a mammal and a whale being both a fish and a mammal. She explained that she would classify bats as birds and whales as fish when taught under the units on animals physical characteristics and movement, However, when taught under animal reproduction, she would consider bats and whales as mammals as they reproduce by giving birth.

R: We take the first session of two lessons when you taught the turtle reproduction first. In your introduction, you asked the pupils about bats. Which group does the bats belong?

Pn. Fatimah: For me, bats are in the group of birds.

R: How do they reproduce?

Pn. Fatimah: They reproduce by giving birth.

R: Where do you get this example?

Pn. Fatimah: I read from somewhere. When I taught, I used it automatically. It just came to my mind.

R: Aren't bats considered as mammals?

Pn. Fatimah: They are mammals. From the book, according to the classification of animals, they [bats] are classified as birds.

We were trying to look through the book which the teacher used to check whether we could find the classification for bats. We could not find it.

R: Can an animal be in two groups? Both birds and mammals are under the vertebrates which have five groups.

Pn. Fatimah: If I am not mistaken, bats are in the group of birds but reproduce differently by giving birth. They are also mammals. For me, I base it on the book. I have read from an encyclopaedia that bats are in the group of birds but reproduce by giving birth. This means they are in both groups, that is birds and mammals.

R: Bats give birth and so they are mammals and not birds. Similarly for whales, they are not fish because of their characteristics like they give birth, provide milk for their young ones, use lungs to breathe. We need to rectify that whales are not fish but are mammals. The name in Bahasa Malaysia is confusing as whale is called 'ikan paus' ('Ikan' means fish)

Pn. Fatimah: It is like this. We have two topics. One topic before animal reproduction concerns the physical characteristics of animals. The other topic is on animal reproduction. According to the physical characteristics of animals, we have to tell the pupils that bats are birds and whales are fish. Bats have wings like the birds. Whales swim, live in the water and have fins.

R: Are the wings of bats like those of the birds with feathers?

Pn. Fatimah: No. The wings of bats have skin connected. Bats have fur and not feathers.

R: Even if we look at the physical characteristics, are they in the same group as birds?

Pn. Fatimah: Yes. But when we touch on the movement?

R: Is movement considered as a physical characteristic?

Pn. Fatimah: No. We are confused a bit. There are three topics: physical characteristics, the movement and reproduction. When we teach about physical characteristics, we tell them bats are birds. When we teach about reproduction, we tell them bats are mammals. When we teach about movement, bats are birds. These are small topics. We have to teach step by step and cannot mix them up. This is what I understand. I do not know whether it is true or not.

R: Bats and whales are mammals.

(S2:T3:I4:P1&2)

Consequently, Pn. Fatimah's pupils have developed similar understanding of these concepts as can be seen from the following extract from one of the lessons observed.

Pn. Fatimah: Which group of animals do bats belong to?

P(c): Mammal.

Pn. Fatimah: Yes. But in which group?

P(c): Bird.

Pn. Fatimah: Bats are mammals which give birth and belong to the bird group.

(S2:T3:O1:P1)

Pn. Fatimah has not understood the concept of the embryo in a frog egg. In one of her lessons, she told the pupils, "The frog egg has the black dot on it and that is why the frog has black dot on the body" (S2:T3:O2:P1).

In the extra lesson on plant reproduction that was observed by the researcher, Pn. Fatimah had problems with terms like pollen, stamen, cross pollination, wind-pollination and insect-pollination.

Pollens are fine powder-like substance found on the male pollen which is called stamen. Pollination is the process of transfer of male pollen (stamen) to female pollen (stigma).

(S2:T3:O4:P1)

There are two types of pollination. One is called self pollination which means the transfer of stamen to stigma on the same flower. The other one is called cross pollination which occurs between two flowers. The two flowers have to be from different trees of the same type. If it is self pollination, it is from the same flower.

(S2:T3:O4:P1)

Pn. Fatimah: In your opinion, which flower is better? Those which are pollinated by insects or wind?

P(Chorus): Insects.

Pn. Fatimah: Why is that? Give your opinion. Who can explain why? Those pollinated by insects are more beautiful and fragrant. For wind, not all stick on to the female pollen.

Teacher held two hibiscus flowers, one in each hand and asked which one is larger, more beautiful. Pupils seemed to agree that the one on the right (brighter in colour) which is more beautiful.

Pn. Fatimah: This may be because it is distributed by insects.

(S2:T3:O4:P2)

Pn. Fatimah admitted facing problems in understanding scientific terms particularly from 'Earth and the Universe'. She would look up new terms in the dictionary or referred to other teachers to understand them.

> Actually there are a lot of problems in science as there are a lot of new terms and new words. When we find it difficult, we refer to the dictionary and we also discuss among ourselves. Topic like planet has a lot of difficult words. Scientific language is difficult. This is especially so in 'Earth and the Universe".
>
> (S2:T3:I1:P2).

Pn. Fatimah would not ask questions if she did not know their answers even if the questions were directly related to the lesson.

> R: In the third session of your lessons on animal reproduction, you asked about the gestation periods of human and monkey. Why is it that you did not ask about the gestation periods of other animals?
>
> Pn. Fatimah: Because for the other animals, I am not sure about their gestation periods. When I am not sure and the pupils ask more question, I will find it difficult to answer. So I used examples which I could answer.
>
> (S2:T3:I4:P6)

Teacher's understanding of the curriculum

> R: What is the role of the teacher and pupils as suggested in the new curriculum?
>
> Pn. Fatimah: We as teachers present information and knowledge, and the pupils are the receivers.
>
> (S2:T3:I1:P5)

Apparently for Pn. Fatimah, the new curriculum had not diverted from the teacher's role as transmitting knowledge to the pupils who are the knowledge recipients. However, she felt that the new curriculum had something else to offer. She said, "Besides emphasising on knowledge, it is to open up pupils mind to get plenty of ideas so that they can think" (S2:T3:I1:P3). According to her, the new curriculum encouraged pupils to investigate and think, and the strategies advocated in the curriculum were activity-based and experiential learning.

> R: What strategies are suggested in the syllabus?
>
> Pn. Fatimah: Do practical, the real one. It needs more practical and by using real things. For example, if we teach about plants, we have to show them real plants. From my understanding, there should be more practical.
>
> R: What about the topic on animal reproduction?
>
> Pn. Fatimah: If we can get, actually we must use the real animals. Because we find it difficult to get the animals, we use pictures and charts. Science actually requires pupils to investigate.
>
> (S2:T3: I1:P4)

Pn. Fatimah's understanding of scientific skills and thinking skills was vague as is revealed in the following conversation in an interview.

Pn. Fatimah: It emphasises observation, investigation, making inferences and identifying. These are the scientific skills. Thinking skills are like making note, contrasting and comparing.

R: What about communication?

Pn. Fatimah: You mean to communicate with each other. It is a thinking skill.

R: What about to guess, to predict?

Pn. Fatimah: They are also thinking skills and they also include classification which is often used in the living world.

(S2:T3:I1:P3)

She attributed her lack of understanding of these skills to the ineffectiveness of the lecturer involved in the in-service course she attended. She commented, "When I attended the course, there was one lecturer whom I could not understand. Many in the class also did not understand" (S2:T3:I1:P4).

Pn. Fatimah's lack of understanding of scientific skills was further revealed in her three lesson plans on animal reproduction. Here, she referred scientific skills to identifying, knowing, collecting, differentiating, making inference, listing, and taking note (S2:T3:D1). The following conversation during the stimulated recall interview further illustrates her confusion between scientific skills and scientific attitudes.

R: How did you incorporate scientific attitudes into your lessons on animals reproduction?

Pn. Fatimah: Is it like making inference, understanding?

R: It is like open-mindedness, listen to other's ideas, having evidence.

Pn. Fatimah: I have never used scientific attitudes. I am sorry. As far as I know, in the lessons plans, I only use thinking skills and scientific skills.

R: What about moral values?

Pn. Fatimah: Sometimes I write, sometimes I don't write.

R: I mean whether you incorporate moral values in the lessons that I observed.

Pn. Fatimah: I am not clear.

R: What about manipulative skills?

Pn. Fatimah: Because I do not use this, so I am not clear.

R: It refers to the skills involved in using equipment.

Pn. Fatimah: I am not clear.

R: How did you incorporate thinking skills in your lessons?

Pn. Fatimah: Do you mean the thinking skills for the teacher or the pupils?

R: For the pupils.

Pn. Fatimah: Through questions and answers.

R: What about scientific skills?

Pn. Fatimah: When we ask them to do work.

R: Like observation. Did you incorporate observation into your lessons?

Pn. Fatimah: When we discuss with the pupils during the explanation.

R: What about observation?

Pn. Fatimah: When we used charts or if there was no charts, when we used books.

(S2:T3:I4:P7&8)

Use of curriculum materials

Pn. Fatimah did not find the pupils' textbook and the teachers' guide helpful in her lesson preparation and preferred to use the school-adopted reference book (S2:T3:I1:P5). Pn. Fatimah chose examples of animals found in the reference book. According to her, the availability of charts of these animals made it even easier for the teacher.

R: Why do you choose certain animals like turtles, frogs, flies, grasshoppers, butterflies and mosquitoes?

Pn. Fatimah: These animals are in the book. We read about them before we teach. Moreover, there are charts. So it is easy for us. If we use other examples, we do not have the charts.

(S2:T3:I4:P5)

She would not consider teaching content which she felt was outside the topic. For example, she would not ask the pupils to observe the differences between male and female grasshoppers as this was not required in the curriculum.

R: Do you think you can ask them to observe the difference between the male and female grasshoppers. Do you think it will arouse pupils interest?

Pn. Fatimah: It will attract their interest. But, there is no topic in the curriculum which requires to differentiate the male and the female grasshoppers. They are only required to know about the breathing of grasshopper, the position of the head, the thorax, how many wings - the physical features only. There is no topic related to the male and female grasshoppers.

R: Isn't this related to reproduction?

Pn. Fatimah: There is some connection.

R: So you think it is not suitable.

Pn. Fatimah: It is not suitable.

(S2:T3:I1:P4&5)

Teacher's view of pupils' understanding

Pn. Fatimah judged her pupils' understanding by their ability to answer the questions in the exercises provided in the pupils' workbook. All questions were low-level convergent type, asking for examples of animals that lay eggs and animals that give birth, and the names of the developmental stages of mosquitoes (Kamaruddin, 1995, pp. 36 & 37). She seemed to believe that repeated explanation would help the weak pupils to understand.

> Pn. Fatimah: When I gave them exercise to do, some of them could score 90%. There I can test whether they have understood or not. If many fail or get low marks, I will repeat the lesson.
>
> (S2:T3:I4:P3)
>
> R: You have mentioned the difficulty of teaching weak pupils. Do you use different strategies to teach the weak pupils?
>
> Pn. Fatimah: I did not do it for this year. I put the weak pupils in a separate group. While the others are doing work, I will explain to them. After they have understood a little, they will join the rest.
>
> (S2:T3:I4:P8)

Pn. Fatimah believed that pupils' intelligence accounted for their ability to understand certain concepts. Her understanding of intelligence seemed vague ~~and distorted~~. For example, in the following extract, she understood it to be pupils' lack of intelligence that prompted them to ask questions. It did not seem to occur to her that teacher's teaching strategies could play an important role in pupils' learning process.

> Pn. Fatimah: Sometimes teacher understands but it is difficult to present it to the pupils. Sometimes pupils argue and do not accept that the earth is spherical and round. It is difficult for us to tell them. According to them, the earth is flat. Some of the pupils' IQ is not very good. They asked things like 'Why do we walk flat?' Another problem is the movement of the earth around the sun and moon around the earth. The bright ones can accept. To convince the pupils is a problem.
>
> (S2:T3:I1:P2)
>
> R: What about teaching the distance the distance of moon from the earth?
>
> Pn. Fatimah: This also has problem as this involves mathematics. If in bright class they can understand as we can use examples.
>
> (S2:T3:I1:P2)

Use of resources

Pn. Fatimah was happy with the flexibility of the system of borrowing things from the science room in her school.

R: Do you have to get permission or can you take out the things from the science room quite freely?

Pn. Fatimah: Even though I am also a science teacher, we have to go through the Head of Science. We do not have to record it. We just have to tell her the things and the quantity that we take out. We put it back straight away after use.

(S2:T3:I1:P1)

However, Pn. Fatimah revealed that when it came to using common equipment like television, video cassette recorder, she did not feel free to use them and had never tried to use them before (S2:T3:I1:P1). She admitted that she had frequently used charts in her lessons while slides and video were not used even though they were among the suggested activities in the syllabus guide (S2:T3:I1:P2). Apparently, she knew where to get these resources, but did not put in effort to get them. She said, "I might be able to get it from the resource centre in the education department or I can record it from television programs. They often show animals and plants life and other science-related topics." (S2:T3:I2:P2).

However, Pn. Fatimah had yet to obtain any teaching materials from the education department resource centre or videotaped television programs for her science lessons. According to her, teachers in the school were overworked which left them with little time to look for materials or prepare their own materials for their lessons.

Our school has a lot of activities. It is not difficult but we do not have time. We even have to come on Saturday. May be only once a year we go to the resource centre in the education department because we do not have time. Every teacher is very busy preparing both his or her own work and work for the pupils.

(S2:T3:I1:P2)

Teacher's understanding of instructional strategies

Pn. Fatimah believed that effective science teaching should involve "more activities, more practical and more materials" (S2:T3:I2:P5). She believed that practical work not only helped pupils to understand concepts, but pupils also enjoyed doing practical work rather than just listening to the teacher. Generally, Pn. Fatimah talked positively about the various teaching-learning strategies such as experiments, demonstrations, visits, projects, pupils discussion, teacher explanation, quizzes, games, drama and invited speakers. For example, she talked about the benefits of visits and projects as follows:.

Visits are very effective as the pupils enjoy it. Visits to the milk factory will enable the pupils to know how milk is processed. Otherwise, they drink milk everyday but they do not know how it is processed.

(S2:T3:I3:P1)

> Projects - Last year, we planted using seeds. I asked pupils to bring soil, seeds, pots. They brought seeds which were easily available like seeds of long beans and short beans. They planted these in groups under the supervision of the teacher. ... We had competition among groups to see which group grew the most healthy plants. In this way, we created interest among pupils.
>
> (S2:T3:I3:P2)

However, she did not seem to practise what she preached. Fear of losing control of pupils, pupils' safety issues, the tedious procedure, and unavailability of resources, were some of the reasons she used to explain why certain instructional strategies were not feasible despite their benefits.

> We are not encouraged to use games because it will disturb other classes. If the teacher wants to do it, it has to be a silent game. In this school, pupils are expected to be quiet and listen attentively to the teacher during the lessons.
>
> (S2:T3:I3:P4)

> The teacher has to be responsible if anything happens to the pupils. For example, we ask the pupils to act out the movement of the frog and we have to take the pupils outside the class. Sometimes they might fall or some sort of accidents can happen. We might get complaints from the parents.
>
> (S2:T3: I2:P2)

> Invited speakers - It has to go through a lot of procedures. It has to be through the head of the unit and the head teacher. It could take a long time.
>
> (S2:T3:I3:P3)

Pn. Fatimah did attempt to introduce practical work into her lessons. Analysis of pupils' exercise books indicates that she had assigned a lot of drawing for her pupils in her science lessons since the beginning of the school year. It is possible that she saw drawing as a 'practical activity' which her pupils enjoyed doing and at the same time an activity devoid of the other problems mentioned earlier. In the following extract, Pn. Fatimah justified the drawing activity as a way of reinforcing pupils' memory. However, she was uncertain of how the activity could enhance pupils' learning.

> R: You used about 30 minutes for pupils to draw diagrams of turtles laying eggs. Do you have any specific objectives in mind?
>
> Pn. Fatimah: Yes. If we explain only without drawing, they will forget. If they draw, they learn drawing skills. They can also appreciate the various stages of how turtle reproduces.
>
> R: Besides learning the drawing skills, what other scientific skills do they acquire?
> Pn. Fatimah: There must be. One of them, they can know, concentrate on what they do.
>
> (S2:T3:I4:P2&3)

6.6.4 Summary

Pn. Fatimah was an experienced teacher who displayed good classroom management. She had a warm and motherly personality and was well liked by her pupils. She showed lack of understanding in several science concepts and had misconceptions about them. What concerned the researcher was that she seemed to be unaware of her own inefficacy. Though she talked about her difficulties in understanding many scientific terms and concepts, she sounded quite pleased that she had understood them after referring them to the dictionary or asking the other teachers. Consequently, her misconceptions of these concepts were passed on to her pupils. A further concern arose as she often acted as a mentor to another science teacher who frequently turned to her for advice and suggestions, which meant her weaknesses were replicated.

Pn. Fatimah understood that the primary science curriculum encouraged activity-based and experiential learning. At the same time, she described "we as teachers present information and knowledge and the pupils are the receivers". Though she could correctly name observation and drawing inferences as two scientific skills, it was obvious that she did not have a clear understanding of what they were and how these skills could be incorporated into her lessons. As there was no deliberate attempt to incorporate these skills into her lessons, the pupils did not have the opportunity to develop these skills.

Pn. Fatimah chose not to use any animal specimens in her lessons on animal reproduction, thus depriving her pupils of hands-on experiences in their learning. She did not explore the possibility of the use of other resources such as slides, video, and books. Instead, she chose copying diagrams from the books as the main practical activity throughout her lessons. As drawing took up a big portion of the time, she rushed through her explanation, without providing time for reviewing and summarising the concepts learnt. She did not provide opportunities for pupils to express and reflect on their ideas. She regarded teachers and the textbooks as the only source of information for the pupils. However, Pn. Fatimah seemed to be an enthusiastic teacher who was keen to learn, and generous to share what she knew.

CHAPTER SEVEN

DISCUSSION

This chapter discusses the findings of the study across the five case study teachers, in relation to the following research questions which were raised earlier in Chapter Four.

1. What are the teaching practices of the five Malaysian primary case study teachers in their science classrooms?
2. What are their understandings of the Malaysian Primary Science Curriculum?
3. What are their conceptions of science teaching and learning?
4. What are some other problems faced by these teachers in implementing the primary science curriculum?
5. To what extent have these teachers implemented the Malaysian Primary Science Curriculum?

7.1 Discussion of Research Findings

7.1.1 Teachers ' classroom practice

i. Classroom management

All the case study teachers were authoritarian in managing their classes and interacting with their pupils, emphasising attentiveness, formality and orderliness in their lessons. This was done by using a number of subtle strategies built into their day to day classroom routines. All pupils in the class would stand up to greet the teacher when the teacher entered the class and thanked the teacher upon the teacher leaving the class. Chorus greeting was normally led by the class prefect to maintain order. Pupils were expected to raise their hands when they wished to answer. Only when the teacher called upon a pupil to answer, would the pupil then stand up to give the answer. Occasionally, when some pupils gave their answers without being called upon to do so, the teacher would remind them to wait to be called before they could answer. In this way, these teachers were seen as consistent in their instructions. As teachers normally anticipated some noise especially during group work, they would spell out acceptable and non-acceptable behaviours. In one of the lessons observed, the teacher instructed her pupils before they started the group work of preparing charts, "You can stand up to do the work but do not make noise".

All the five teachers were warm, friendly and pleasant, and seemed well liked by their pupils. They were able to establish a seemingly conducive learning environment with little disruption and pupils were seen to be conscientiously engaged in tasks set by the teachers. Even in lessons where some pupils were seen whispering among themselves, which could often be an indication of them getting bored and restless, they continued to appear to listen to the teacher and carry out the tasks set by the teacher. It appeared that these pupils had internalised their standards for behaviour which was further facilitated by social and school cultures, which put great emphasis on discipline and respect for teachers.

ii. Instructional strategies

All the teachers in this study used teacher explanation as the main instructional strategy throughout the lessons observed. Generally, they practised whole class teaching and group work was rare, despite group learning being advocated as one of the key features for all subjects across the primary curriculum. Teachers made very minimal contact with individual pupils and very little verbal interaction was observed between the teachers and their pupils. The only form of verbal interaction that occurred in the lessons was in the form of question-answer sessions. According to Tabulawa (1998), managing classroom interaction in this way enabled teachers to effectively remain in control of the class.

There is an abundance of support in the literature which points to the importance of minds-on experiences going hand in hand with hands-on activities to ensure meaningful learning (Brophy, 1998; Harlen, 1992; Millar & Driver, 1987; National Research Council, 1996; Raizen & Michelsohn, 1994; Roychoudhury, 1994; Tobin et al., 1994). Inevitably, cognitive engagement is considered to be the key to the effectiveness of good activities. According to Brophy, the success of an activity in producing thoughtful student engagement with key ideas, depends not only on the activity itself, but also on the teacher structuring and the teacher-student discourse that occur before, during and after the activity. Raizen and Michelson reported that the minds-on component of a science activity which is regarded as one of the most difficult aspects, but the most essential part of science teaching, is often overlooked. Findings of various studies carried out to investigate the effectiveness of practical activities in science revealed that, this lack of students' thinking processes behind the physical activities, had resulted in the ineffectiveness of such activities (Lunetta & Tamir, 1979; Solomon, 1992; Stake & Easley, 1978).

In this study, hands-on activities were not common. When the activities did occur such as drawing or making charts, hands-on with no minds-on was conspicuous. Four of the teachers assigned their pupils to prepare charts on animal reproduction. In all of them, pupils were merely engaged in physical activities such as cutting, colouring, pasting or drawing pictures of various animals. None of the teachers structured these activities to involve pupils' cognitive engagement. There was no opportunity for pupils to share and reflect on what they were doing, neither was there any opportunity for their peers to critique their work. The teachers' main concerns seemed to be ensuring that their pupils followed the procedures correctly, had the right pictures on the charts, and completed the tasks within the allocated time. In the lessons where two of the teachers showed videotapes and slides, pupils merely watched the slides and videotapes and listened to the teacher's explanation. To guide pupils' thinking while viewing the slides and videotapes, pupils could have been given a series of questions to answer as the lessons unfolded. However, none of these or other relevant cognitive activities took place. The charts or scrap books making became simply an activity to fill up the lesson time, and the slide or video show became mainly an entertainment.

Trying to cover too much content within a limited time period might also explain why little minds-on activities were observed in the lessons. Brophy (1998) critiqued those curricula which over-emphasise breadth of coverage at the expense of depth of topic development, and the textbooks that "offer parades of disconnected facts instead of coherent networks of connected content structured around powerful idea" (p.39). Consequently, many teachers choose breadth of coverage over depth of topic development. In a hurried attempt to cover too much content, little or no time is left for pupils to engage in meaningful hands-on and minds-on activities that will enable them to gain proper understanding of key ideas.

The teaching practices of the five teachers in this study seemed to focus on broad but shallow coverage of disconnected content to get through the curriculum topics. They frequently talked about not knowing "how much is required". All of them attempted to include all the animals mentioned in their references, such as the teachers' guides and other commercially published textbooks. Birds, frogs, turtles, mosquitoes, cockroaches, grasshoppers, houseflies, and butterflies as examples of animals which lay eggs were all mentioned in two lessons of 60 minutes. The teachers managed to cover superficially the reproduction of all of these animals within the required time. However, they did not provide any opportunity for pupils to observe the animals in their various stages of development, compare the similarities and differences, or discuss the key ideas. The study of one insect with complete metamorphosis, and one with incomplete metamorphosis, could have been adequate to enable the pupils to learn the key ideas of insect reproduction. The reduction of five insects to two insects would leave more time for the pupils to engage in activities which can help them to gain better understanding of the two insects, after which they can relate the key ideas to those of other insects.

Two of the teachers attempted to get the pupils to present their finished charts on life cycles of insects. Pupils copied the diagrams from their school-adopted textbook which did not contain any textual information about the life cycles of these insects. The pupils seemed to be at a loss as to what they were expected to present. In one class, the first group of pupils who were asked to present their work, came up with the idea that two of them would hold the chart and another pupil would read out the title of the chart followed by the terms for the developmental stages of the insect. It is interesting to note that this group had acted as the role model for all the remaining groups in the presentation of their work. Obviously, this group of pupils were unable to provide the role model for the development of communication skills. In this case, teachers could have been the role model advocated in the cognitive apprenticeship model (Collins et al., 1989) to enable pupils to develop communication skills. This approach requires the teacher to model the required skills, and to provide the scaffolding within the pupils' zone of proximal development (Vygotsky, 1978) in ways that allow them to handle as much of the task as they can with guidance from the teacher and to progress toward fully independent and successful performance (Brophy, 1998). After the teacher demonstrates the relevant communication skills, pupils can be asked to present their work in front of the class, during which the teacher can assist pupils in diagnosing their mistakes, and improving the required skills. As both these case study teachers did not provide any modelling, coaching or scaffolding, their pupils advanced very little in their communication skills, despite given the opportunity to involve in tasks which were highly relevant for the development of such skills. The pupils merely stated the terms for the various developmental stages of the insects during their presentations. They could have been encouraged to make comparison between the various stages of development of the insect assigned to them, and to compare them with those of the other insects. However, this was not done. As such, it would be difficult to judge whether these pupils had understood the key ideas regarding insect reproduction. Teachers need to be aware of the potentials of the various tasks assigned to the pupils, for example, the type of behaviour, attitudes and cognitive processes. This would help to ensure that pupils are provided with the opportunity to engage in physical and cognitive activities to produce the desired outcome.

As early as twenty years ago, Shymansky (1978) suggested that science teachers should tailor instruction to pupils' individual needs by using multiple methods of teaching. According to Shymansky, "rather than worrying about the correct decision on the use of highly verbal materials, structured or unstructured activities, open-ended or cookbook experiments, try making both options or several options available" (p.38). Recent critics of learning styles research have also questioned the validity of the suggestions made to teachers to differentiate curriculum and instruction catering for student individual needs (Brophy, 1998). Brophy pointed out that catering solely to students' existing preferences might not be in the best interests of the students in the long-run. For example, the strategy of one teacher in this study who described her pupils as weak and were seen by her as interested in drawing, thus occupying them mainly with drawing activities while leaving little time for gaining meaningful understanding of the key ideas or the development of other skills. It is questionable whether this was in the best interests of the pupils. According to Brophy, it is necessary for students also to learn to function effectively in situations that call for their non-preferred cognitive style. He believed that it was more beneficial to focus on students' learning goals, values and expectancies than on the variables emphasised in learning style inventories. Besides, Brophy also raised the practical constraint of feasibility of those teachers who have to work with 20 or more students. It would be even more difficult for the teachers in this study who had to work with 50 pupils in the class. Multiple methods of teaching not only takes account of the needs of individual students at some stage, it is the only way to enable pupils to develop a wide range of scientific skills and scientific attitudes.

The teachers in this study used teacher explanation as the main teaching strategy throughout the whole unit on animal reproduction. There was no attempt to use a wider range of instructional strategies to enable the pupils to develop the various skills and attitudes advocated in the curriculum. For this particular unit, it would not be difficult to introduce multiple methods of teaching. Piaget's stage developmental theory emphasises the importance of concrete and realistic experiences for pupils at the primary school level to provide the underpinnings for later more abstract learning expected at the secondary school and university levels. Basic concepts of animal reproduction could be learned through first-hand experiences with animals such as cockroaches, grasshoppers, frogs, mosquitoes which were readily available in the local environment.

All the five teachers in this study used charts consisting of pictures of various stages of development of different animals. None of the them used the animals despite them being readily available in the local environment. Eggs of cockroaches were easily obtainable, and pupils could observe the transformation of eggs into nymphs before developing into adult cockroaches. Houseflies could have been kept in containers to allow them to mate and lay eggs where pupils could observe the change of eggs into larvae, pupa and housefly. Pupils could observe the transformation of caterpillars to chrysalis to moths or butterflies. Tadpoles were also readily in streams and ponds. These activities could have easily provided a basis for observation, data collection, reflection, and analysis of first-hand events and phenomena. These activities could have been used to help the pupils to reach a deepening understanding of the meaning of the term cycle in living things. "A luna moth breaking out of its chrysalis in the classroom after weeks of study and observation captures the fancy of students in a way no textbook description can match" (Raizen & Michelsohn, 1994, p.41). Pupils could also be encouraged to draw based on their observations, and perhaps compare them with the drawings in the books. Tamir (1985) suggested that pupils can also be encouraged to participate in the critical analysis of secondary sources such as media and books which in this case, is suitable for gathering information about the larger animals and animals which are inaccessible to the pupils.

First-hand experiences with the animals as described above, not only bring about more meaningful understanding of various factual information about these animals, but also facilitate the development of a wide range of skills and attitudes. Pupils can learn the skills of setting up vivariums for different animals, and the skill of observation using the naked eyes as well as with the help of magnifying glasses. They could also learn the skill of manipulating variables to provide the right conditions for the well being of the animals. Having learnt to take care of these animals and observed their characteristics closely, pupils may even become fascinated with animals which may have seemed uninteresting or even repulsive to them initially. In this way, pupils can develop respect for all living things including those which may not seem significant to them before.

Table 7.1 comprises the various activities suggested for 'Animal Reproduction' in the curriculum materials such as the curriculum guide, the pupil textbooks and the teachers' guides. The scrap books / charts activity was suggested in all of them. However, the activities to carry out projects to reproduce animals suggested in the curriculum guide have been left out in all the other documents. It is rather incomprehensible why these relevant and meaningful activities, which could provide first-hand experiences to the pupils, had not been included in the teachers' guides or the textbooks. All the teachers in this study justified their use of the scrap books or charts making activity in their lessons by saying that this activity was found in the teachers' guides or the textbooks, with little or no reference to its learning potentials for the pupils. Moreover, the classroom observations of the two Chinese school teachers provide little evidence of any discussion based on the pictures in the pupil textbook. The inclusion of the activities to carry out projects to reproduce animals in the teachers' guides and the textbooks, might have increased the chance of teachers using these activities in their lessons.

Table 7.1: Suggested Activities for 'Animal Reproduction' in the Curriculum Materials

Curriculum materials	Suggested activities
1. Curriculum guide	1. Recording and arranging information about animal reproduction by the preparation of scrap books or charts. 2. Carry out projects to breed animals.
2. Pupil textbook (Bahasa Malaysia)	Making scrap books of animals with pictures and stating their mode of reproduction.
3. Teachers' guide (Bahasa Malaysia)	Making scrap books of animals with pictures and stating their mode of reproduction.
4. Pupil textbook (Chinese)	1. Collecting pictures of animals. 2. Discussion based on the pictures.
5. Teachers' guide (Chinese)	1. Collecting pictures of animals. 2. Discussion based on the pictures.

iii. Questioning techniques

There is general agreement that asking questions is an important dimension of teaching (Harlen, 1992), and therefore, teachers' ability in effective questioning techniques is crucial to their success as practitioners in the classroom (Woodward, 1992). All the five teachers asked a number of questions in their lessons. In all the classes, regardless of the level of pupils' ability, most questions were confined to those which were low-cognitive nature, involving eliciting right answers to miscellaneous factual questions. There were very few questions which could stimulate pupils to think about the content, to relate it to their prior knowledge, and to explore its applications. While pupils seemed to be good at providing short factual answers to these questions as they were probably accustomed to it, they faced difficulties in expressing their ideas in proper sentences. Though Brophy (1998) agreed that the occasional use of low level cognitive questions could be used to reinforce learning that must be memorised and to check and correct understanding of basic knowledge, he reiterated the importance of asking more thought-provoking questions in order "to build an integrated network of knowledge structured around powerful ideas" (p.189).

The teachers in this study asked very few higher-level cognitive questions which required skills such as reasoning and interpretation. The two teachers who had studied pure science in their secondary education did ask a few higher-order questions. This seems to lend support to Bennet and Carré's finding (1991, cited in Woodward, 1992) that teachers who did not have the subject knowledge were restricted by the background from which they could draw higher order questions. This might help to explain why the three teachers who had not studied pure science during their secondary education, did not ask any higher order questions. Woodward (1992) suggested that teachers' lack of confidence in their own understanding of the subject area might be one possible reason for teachers' reluctance to ask higher order questions to their pupils. These three teachers in the present study admitted to not asking questions to which they themselves did not know the answers as they did not want to put themselves in an awkward position.

However, Woodward (1992) regarded it as necessary for teachers to have both a depth of subject knowledge and the skills of effective questioning. Dillon (1988) recommended that teachers should ask fewer questions, thus allowing more waiting time for pupils to respond. Questions should include higher-level cognitive questions which could engender genuine discussion rather than the 'guess what the teacher's thinking' type. Furthermore, teachers should foster an atmosphere of inquiry which encourages pupils to ask questions. These same questioning techniques which were found to be effective in facilitating pupils' learning were cited in literature two decades ago (McGlathery, 1978). These questioning techniques are also among the descriptors of constructivist teaching behaviours described by Brooks and Brooks (1993).

The teachers in this study demonstrated questioning techniques which did not fit well with the skills of effective questioning just described. The two teachers who did ask some higher order questions were not able to maximise pupils' learning potential from these questions, due to their lack of skills in effective questioning. Pupils' alternative explanations of phenomena were not encouraged, with only one or two pupils being given the opportunity to express their ideas. Many pupils faced difficulties in expressing themselves clearly. Their ideas were largely ignored as they were often different from those expected by the teachers. Hardly any wait time was allowed for the pupils to respond to the teacher's questions. The teachers would then continue by providing the 'correct' answers which were answers found in the books. Teachers' attitudes to knowledge were closed where they saw themselves as authorities dispensing information rather than as one of the many sources of information. This 'right-answerism' phenomenon was also found to be common in Botswana classroom (Tabulawa, 1998; Prophet, 1990). Tabulawa described asking closed-ended questions which demanded definite answers as the teachers' way of ensuring that they remained in control of the interactional situations. According to Tabulawa, "The danger with open-ended questions was that they may yield unpredictable answers that may put the teacher 'off-balance' resulting in a possible loss of classroom control" (p.258). This seemed to be a serious concern among the teachers in this study, particularly those who lacked proper understanding of the subject area they were teaching.

Another conspicuous feature in all the lessons was the lack of pupil-initiated talk in the classrooms. Pupils did not ask any questions aloud in the class. Pupils may have regarded it as the teacher's duty to ask questions rather than part of their own responsibility in the learning process. This could be linked to the Malaysian culture where asking teachers questions is regarded as challenging or questioning the teachers' competency, thus indicating a sign of disrespect towards the teachers which is considered an unacceptable behaviour (Ling & St. George, 1998). However, during the group work on doing charts, some pupils did approach the teacher individually to ask for information such as whether a certain animal lays eggs or given birth, or checking for certain procedures such as where the title of the chart was to be placed. According to Jelly (1985) and Woodward (1992), children learn their question-asking habits from their teachers. It came as no surprise that pupils in this study asked only low-level questions as they were scarcely exposed to higher-level questions. Woodward suggested that it was necessary for teachers to present a model which could be emulated by the pupils, and that this was particularly important in the case of children who were in the early stages of learning how to pose a question. Some suggested that pupils need to be equipped with the ability to formulate questions and this is a skill which needs to be taught rather than left to chance (Dillon, 1988; Jelly, 1985).

Analysis of teacher-made tests and examinations, and the exercises contained in the workbooks and other school-adopted textbooks, revealed widespread reliance on low-level recognition or memory reproduction items calling for matching, true/false, or fill-in-the-blank responses, and lack of questions of higher cognitive skills. In this way, both teachers and pupils were constantly exposed to questions of low cognitive skills and had little exposure to questions involving higher order cognitive skills. Once again, pupils lacked the type of teacher role model as described in the cognitive apprenticeship advocated by Collins et al. (1989) as necessary to learn to ask more higher order questions. This means that teachers will have to reflect and re-examine the effectiveness of their questions, to ensure better quality questions to be asked in their class, in the exercises given to the pupils, and in the tests and examinations.

iv. Role of pupils' prior knowledge

None of the teachers in this study appeared to give due recognition to pupils' pre-existing knowledge in the learning process even though they realised that pupils had prior knowledge about the reproduction of pet animals such as dogs and cats. They only asked the pupils about the number of new born of these animals, while none of them asked about other aspects such as how these animals took care of their young ones. They did not seem to regard the pupils' experiences and prior knowledge relating to these experiences as important bases upon which to build their understanding of concepts. Therefore, these prior conceptions on which to develop understanding of new concepts, were not explored in greater details, thus depriving the pupils the opportunity to incorporate new knowledge into their old cognitive structure. When pupils gave the 'wrong' answers, teachers provided the 'correct' answers rather than probing or diagnosing pupils' ideas in order to understand why they were incorrect. The reasons behind the pupils' answers were not explored, and the pupils' understanding was not further probed either during or after the explanation.

These teachers' conceptions of how pupils learn are inconsistent with the conceptual change learning model proposed by Posner et al (1982) which advocates that new knowledge has to be firmly anchored to existing knowledge, and interactions between existing knowledge, the ideas of others, and experiences can lead to existing ideas modified, extended or changed in the process. Cheung and Taylor (1992) described the role of the teachers as one of creating a classroom atmosphere for teachers and students to interact positively with each other where individual's meanings are listened to and respectfully questioned.

Teachers in this study used the conventional instruction in what Perkins (1991) referred to as the 'conflict buried' path, where the teachers assumed that pupils' ideas could be easily displaced with teachers' views or ideas which represented the scientists' ideas. These teachers appeared to hold the traditional view where learning was viewed as a one-way, passive, telling-listening relationship between teacher and pupils and that learning was about filling pupils' empty heads with scientific ideas. Some pupils in one class remained confused about the whale, despite the teacher telling them that the whale is a mammal which gives birth and feeds the new born with milk. When one pupil continued to give whales as an example of egg-laying animals that live in water, the teacher simply repeated, "Not whale. Whales give birth and do not lay eggs". The teacher did not ask for any clarification or explanation, nor did she provide discrepant events or encourage debate and discussion which had been identified by Smith and Neale (1989) as essential in bringing about conceptual change in pupils' ideas. That the pupil in the above example continued to be confused about whales being egg-laying and not giving live birth, is consistent with findings of studies (Novak, 1988) which reported that instructional efforts only directed at teaching the scientific concepts are not sufficient to modify in a positive way the conceptual frameworks of most students.

7.1.2 Teachers' understandings of the Malaysian Primary Science Curriculum

The five teachers in this study clearly understood the difference between the new science curriculum and the 'Man and His Environment' curriculum in terms of content coverage. They understood that while the science topics for both curriculum were similar, 'Man and His Environment' covered a wider range of topics including history, geography, health science and civics. They seemed uncertain when asked about the difference between the teaching approaches for the two curricula. According to one teacher, teachers taught the old curriculum (Man and His Environment) by telling the answers directly to the pupils. All five case study teachers seemed to be aware that the new curriculum advocated pupil-centred, activity-based, and experiential learning. They described the new curriculum as "encouraging pupils to think through the activities", "do practical, the real one", "more practical and experiments by using real things", "show them real plants", "use the real animals", "encourages observation and classification", "requires pupils to investigate". However, none of the teachers' teaching practices fit in any of the described pupil-centred, activity-based and experiential learning. The teachers offered various reasons for not teaching their lessons in accordance with the curriculum requirements. It can be best summed up in one teacher's words, "It is difficult for the teachers to carry it out [pupil-centred, activity-based, and experiential learning] as this requires a lot of materials, a lot of work, requires the teacher to think". A combination of factors such as difficulty in getting the necessary materials, time-consuming preparation, and teachers' lack of understanding of how to do it, seemed to have caused the teachers' reluctance to change their teaching approach to that of inquiry-based learning.

All the teachers in this study showed little understanding of scientific skills, thinking skills, scientific attitudes and moral values as espoused in the curriculum. This, coupled with the pressure to get on through the curriculum, and to prepare pupils for examinations, resulted in teachers emphasising the content part of the curriculum.

This included the three teachers who had attended at least one of the three in-service science orientation courses conducted by the Sabah Education Department. They did not display any better understanding of the various aspects of the curriculum than their two colleagues from the other school who had not attended any such courses. This seemed to indicate that the science in-service orientation courses had not been effective in improving teachers' understanding of the various skills, values and attitudes emphasised in the curriculum, nor in terms of their teaching practice.

As shown in Table 3.2 on page 70 which shows the program of the orientation course for science teachers just before the implementation of the new primary science curriculum where the researcher was a participant, four hours were allocated for 'scientific skills' while two hours each were allocated for 'thinking skills' and 'scientific attitudes and moral values'. The trainers were trying to include as many activities as possible in these sessions. In all the sessions on scientific skills and thinking skills, teachers carried out an activity using each of 12 science process skills and 17 thinking skills found in the curriculum modules. All participants were provided with the curriculum modules on scientific skills (Ministry of Education, Malaysia, 1994b) and thinking skills (Ministry of Education, Malaysia, 1994c). The researcher observed that the participants hurriedly carried out these activities as instructed. There was no time for discussion, reflection and relating these skills to the context of the curriculum. For the session on scientific attitudes and moral values, teachers merely viewed a video tape on a supposedly 'model' lesson focusing on various scientific attitudes and moral values, and they listed down the scientific attitudes and moral values that were observed.

Studies have shown that a hands-on approach and activity-based workshops were desirable and effective for teachers who had difficulties in using formal reasoning patterns in problem solving and were described as being in the concrete operational stage (Mulholland & Wallace, 1996; Tilgner, 1990). The teachers in this research who attended the course spoke favourably of these practical sessions provided in the in-service courses. While the activity-based approach was a positive step in enhancing the quality of the in-service courses, the time constraints seemed to have negated the effect. Mulholland and Wallace described how a slow pace of presentation and a gradual introduction of new ideas and terminology allowed for a more thorough exploration of ideas, thus avoiding the discouragement experienced by teachers who were presented with too many new ideas at one time and ended up with little understanding of these ideas. This could have happened during the course while the teachers were introduced to scientific skills, thinking skills, scientific attitudes and values which were probably new ideas to many of the teachers. This seemed to be the case of trying to cover more content without ensuring understanding. Appleton (1995) suggested covering less content but ensuring understanding would be a more feasible option. According to him, once teachers have understood the underlying philosophy of the new curriculum, they would be able to access other areas on their own. The lack of 'minds-on' in the course might have explained why the hands-on activities on the lessons on animal reproduction were not coupled with the minds-on component of the activities.

Olson (1981) studied the behaviours of teachers implementing the School Council Integrated Science Project (SCISP) and found that when teachers were faced with innovative ideas, they "domesticated" these ideas by translating or modifying them into something which were familiar to them so that it was clearer to them what was to be done. Olson noticed that important elements of the doctrine of the SCISP Project were either ignored or redefined in more traditional terms, and thus, the innovation suffered the fate at the hands of these teachers. According to Olson,

> Discussions became lectures or recitations; intellectual skill development was translated as content memorisation and examination rehearsal; the integrated design was translated as a patchwork of specialised content to be unravelled and resewn; criterion referenced assessment was translated as norm based. (p.265)

Similar behaviour was observed among the teachers in this study. Terms like thinking skills, scientific skills, scientific attitudes and moral values were given meanings in terms of the teachers' existing vocabulary and understanding. They interpreted thinking skills as something which the pupils would have to do in answering teachers' questions, without considering the types of questions asked. These questions and answers are referred to as discussions. For these teachers, scientific attitudes and moral values were being practised by pupils in so far as pupils were seen to obey teacher's instruction such as bringing the necessary materials, sharing tasks in groups, raising their hands when they want to answer, and not making too much noise during the lessons. In terms of scientific skills, the teachers often talked of observation being incorporated into the lessons as pupils looked at the charts used by the teachers or the diagrams in their books. Classifying animals into animals that give birth and that lay eggs was repeatedly used as an example of classification. By explaining thinking skills, scientific skills, scientific attitudes and moral values in these ways, these teachers justified that they had incorporated the various skills, attitudes and values in their lessons. Their lesson plans confirmed their lack of understandings of thinking skills, scientific skills and moral values.

The curriculum materials pertaining directly to scientific skills, thinking skills, scientific attitudes and moral values are contained in three modules published by the Ministry of Education (Ministry of Education, Malaysia, 1994b; 1994c; 1994d). These modules did not seem to offer much help to the teachers to help them to understand these skills, attitudes and values. The two teachers of the Chinese school did not have access to these modules while the three teachers of the National school who had these modules did not seem to find these modules to be helpful in their teaching, even though they had attended an in-service course on the new primary science curriculum. They mentioned that they referred to these modules during the course as they carried out the activities in the modules. Two of the teachers were not sure where they had kept them while the Head of Science in the school had them on her desk but mentioned that she hardly used them. They seemed to belong to the group of teachers described by Roberts (1988) who received a new science curriculum policy document which they would flip through and put it on the bookshelf to gather dust. Roberts suggested the incomprehensibility of the document as being a possible cause. In the modules for scientific skills and thinking skills, each skill is defined following by one or more examples, while in the module for scientific attitudes and moral values, a few indicators are described for each of the attitudes and values. It seems that mere definitions of these skills, attitudes and values with a few isolated examples are insufficient to enable the teachers to understand them fully in order to incorporate them into their lessons.

Other curriculum documents such as the curriculum guide, the teachers' guides and the textbooks, did not offer any useful explanation either. For example, no achievement objectives related to skills and values on 'Animal reproduction' were stated in the curriculum guide. Both the Bahasa Malaysia and Chinese versions of pupil textbook did not refer to them at all. While the Chinese version of the teacher's guide also did not refer to them, the Bahasa Malaysia version of the teachers' guide described the scientific skills, attitudes and moral values for each of the activities. For example, for the activity of making a scrap book on 'animal reproduction', the teachers' guide lists observing, predicting, classifying, and communicating as scientific skills, while interest and curiosity, honesty and precision in measurement, co-operation, open-mindedness, and love for animals are listed for attitudes and moral values. However, no explanation was offered on how these skills and values were to be incorporated into the activity. While observing, classifying, interest and curiosity may seem obvious, others such as predicting, communicating and open-mindedness would require some explanation for the teachers to understand how to incorporate them into the activity. Van Den Akker's (1988) study revealed that structured curriculum materials containing large amounts of specifications on essential elements of the curriculum, were more effective to meet the personal and survival concerns of the teachers particularly at the initial implementation phase. In this case, the curriculum materials which were very brief and unstructured, were not able to offer much help to the case study teachers to understand the skills and values emphasised in the curriculum.

In summing up, these teachers lacked understanding the new curriculum requirements in terms of skills, attitudes and values. Without proper understanding of the various skills and attitudes as espoused in the curriculum, they were not able to plan instructional activities which could provide opportunities for pupils to acquire these skills and attitudes. Therefore, it should perhaps be no surprise that all of them were just transmitting factual information about animal reproduction without giving due thought as to how these skills and attitudes could be incorporated into their lessons. The teachers were concerned, not so much in terms of whether they have taught according to the curriculum requirements in the way science educators and curriculum developers would like, but rather whether they had taught in accordance with the requirement of the assessment system. This was clearly reflected in the words of one of the teachers, "The teachers are worried. We don't know what the Education Department wants us to teach and what type of questions will come out in the exam".

7.1.3 Teachers' conceptions of science teaching and learning

Smith and Neale (1989) described four orientations to teaching and learning science as (i) discovery, (ii) process, (iii) didactic/ content mastery, and (iv) conceptual change. Table 7.2 contains a summary of these orientations.

Without any exceptions, the perceptions of the case study teachers fall clearly under the 'Content Mastery' orientation to science teaching and learning. The teachers perceived school science as a body of facts dealing with names and figures to be remembered and to be regurgitated during the examinations. The teacher who asked her pupils to memorise the distances between sun, moon and earth, related that she could teach easily if she knew a lot about the topic. She expressed her preference to get more help on content rather than teaching methods so that she could increase her knowledge which she could use to present it to her pupils. The teachers perceived their role as transmitting scientific knowledge to the pupils. Generally, they defined the role of the teachers as one of imparting knowledge and skills with pupils absorbing the knowledge. They regarded themselves primarily as sources of knowledge which effective teachers can readily transmit to their pupils. One of the teachers who was reluctant to involve expertise in the community in her lessons because she felt that these experts who were not teachers were not able to speak at the pupils' level which might result in pupils not understanding what they were talking about. Drawing, making charts, repetition, revision and quizzes were regarded as activities which would help pupils to remember the facts. This transmission-reception

Table 7.2: Orientations to Science Teaching and Learning (Source: Smith & Neale, 1989, p.11)

	Science is	School science is	Learning science is	Teaching science is
Discovery	inquiry, discovery of natural laws, curiosity, creativity	inquiry science, exciting, interesting, "hands-on"	discovering with five senses, being curious, interested, trying out ideas, drawing own conclusions, exciting, fascinating	providing materials and interesting activities, encouraging children to try things, motivating children's interest and curiosity, posing questions, managing activities
Processes	scientific method, processes of science	learning scientific method, process approaches	learning steps in scientific method and practising them; observing, drawing conclusions, collecting data, testing hypotheses, inferring, observing teacher model correct steps	demonstrating and teaching steps in scientific method, providing opportunities to practice, maintaining children's correct use of method, managing activities
Didactic/ Content mastery	body of facts, laws, formulas; established by scientists	exposure to content, memorising known facts, laws and formulas, assimilation of known content	reading text, adding on new information, practising, answering factual questions, watching films, listening to teacher talk, being tested, watching demonstrations	presenting content clearly, showing and demonstrating, getting films, asking factual questions, correcting students; errors, giving clues and hints, providing practice, giving tests
Conceptual change	construction and evolution of theories within conceptual ecology; criteria of predictive and explanatory adequacy	focus on fundamental concepts and theories in science, provide opportunities for children to construct and reorganise knowledge	articulating own ideas, predicting, explaining, contrasting alternative explanations, debating and arguing, making sense of discrepant events, solving problems contrasting evidence and predictions	eliciting children's ideas, providing discrepant events, challenging children to predict and explain, contrasting alternatives, presenting scientific conceptions, providing ways to apply new concepts, encouraging debate

pedagogical style is in perfect harmony with the teachers' perspective on the nature of scientific knowledge in relation to the learners.

At no point did any of the teachers describe scientific knowledge in terms of it being something that can be constructed in the classroom. In fact, when asked about the meaning of constructivism, none of them had ever heard of it. There was a total lack of instructional strategies which have been described as crucial in facilitating students' conceptual change in science (Smith & Neale, 1989) These included eliciting students' preconceptions and predictions about phenomena, asking for clarification and explanation, providing discrepant events, encouraging debate and discussion about evidence, and clearly presenting scientific explanations. These teachers did not seem to possess the knowledge related to these teaching strategies.

7.1.4 Other problems faced by the teachers

i. Teachers' understandings of instructional strategies

The teachers seemed to be aware of the benefits of the various strategies such as pupils' experiments, discussions, demonstrations, visits, games and drama. They talked of the benefits of pupils being interested, but they were unable to describe in more specific terms how these strategies could help pupils' understanding. They seemed to be very conscious of the technical problems associated with these strategies. They described these strategies as ideal but impractical in real classroom contexts. Instead of thinking of possible ways to overcome the problems, they appeared to find it more comfortable to use teacher explanation as the main instructional strategy in their lessons. Having to rush through the syllabus, pressure of pupils' performance in exams, pupils' safety, and fear of losing class control were used to justify their frequent use of teacher explanation as the main instructional strategy and their tendency for not using other strategies. Moreover, they viewed science teaching as transmission of scientific knowledge and scientific knowledge as facts and figures. To them, teacher explanation appeared to be the fastest and easiest way to facilitate this transmission process.

The teachers believed that the instructional strategies with a focus on the learner taking an active role, required much time. They seemed to be unwilling to reduce topic coverage in order to increase depth of exploration to achieve conceptual change (Shymansky, Yore, & Good, 1991). While teachers in many Western countries can decide on the matter of topic coverage, Malaysian teachers are legally bound to cover the content specified in the mandated syllabus.

Krugly-Smolska (1990) argued that teachers may be so caught up in the aspect of transmitting knowledge of facts, concepts, principles and theories that there is little time left to think of other aspects such as planning the instructional strategies and obtaining relevant resources. The case study teachers in the present research gave very little thought about teaching strategies and how to incorporate skills, attitudes and values in their lessons.

The teachers described activities as something to be done when there was extra time available. They talked about pupils being interested in doing activities, but none of them had ever thought about how practical activities could help pupils' meaningful understanding of the concepts or the development of process skills. Rather, activities were seen as a solution to break the pupil boredom, to fill the lesson time, and they were carried out because they were cited in the teachers' guidebook.

None of the case study teachers had heard of terms like a constructivist approach to learning, hands-on minds-on, and inquiry learning. Their understanding of different instructional strategies was limited. The one-week orientation course for primary four science teacher held before the implementation of the new primary science curriculum, did not seem to have offered much help to the teachers in terms of better understanding of the use of various instructional strategies and how to use them more effectively in their lessons. This is apparent as the three case study teachers who had attended this course did not employ different instructional strategies in their classrooms. The course allocated four hours to introduce the teachers to science teaching-learning strategies (refer to Table 3.2 on page 70 for the orientation course timetable). During the four hours of the course, a didactic approach was used to introduce teachers to the matters concerning how pupils learn science, the questioning skills, and the teaching-learning strategies as contained in the curriculum module on teaching and learning strategies I (Ministry of Education, Malaysia, 1994e). Research has shown that experienced teachers hold patterns of thought and action that have developed over many years (Hollon et al., 1991; Wallace & Louden, 1992), and that these typically well-grounded implicit theories and conceptions were robust and extremely resistant to change (Weinstein, 1989; Cronin-Jones & Shaw, 1992). Here, the participating teachers in the course would have built up their own conceptions about pupils' learning and various instructional strategies from their years of teaching and learning experiences, and these conceptions were not addressed in the training sessions.

During the course, workshop sessions involved groups of teachers preparing lesson plans and teaching the lessons, without any appropriate modelling and guided practice from the lecturers. With little understanding gathered from the sessions on skills, attitudes and values, and teaching-learning strategies, most of the teachers were probably using their 'well-grounded implicit theories and conceptions' to plan their lessons. Hollon et al. (1991) considered modelling and guided practice as absolutely essential before teachers could be expected to make fundamental changes in their practices in using new instructional strategies. With each group of teachers allocated about half an hour to forty minutes to present their lesson plans and to teach the lessons, there was practically no time for any discussion, reflection or critique of the lessons presented. All lessons presented were based on practical activities and there was an apparent lack of 'minds-on' that accompanied them. The participating teachers did not receive any modelling or guided practice either before, during or after the lesson preparation and presentation. Teachers saw a number of lessons, but little of exemplary inquiry practices involving both hands-on and minds-on. All they saw was probably the emphasis on physical activities. They did not grasp the importance of minds-on process in inquiry learning. Time constraints appeared to have contributed to the failure to address participating teachers' existing conceptions, to the lack of modelling and guided practice, and the lack of reflection and discussion by the teachers after each lesson presentation. Lecturers' incompetence might have been another contributing factor.

The curriculum materials seemed to have offered little help to the teachers in their understanding and use of appropriate teaching and learning strategies and resources in their science lessons to meet the curriculum requirements. The curriculum guide recommends the use instructional strategies such as experiments, discussions, simulations, and projects. Analysis of the curriculum modules on teaching and learning strategies, the operationalising of science process skills and the management of primary school teaching-learning resources reveals that these modules do not seem to be well-designed as they are found to be brief, disconnected and incoherent. For example, there is a series of three curriculum modules on teaching and learning strategies (Ministry of Education, Malaysia, 1994e, 1995c, 1996d). The first module contains brief descriptions on how pupils learn science, questioning techniques and three instructional strategies which included experiments, discussions and simulations. There is no reference to projects even though it has been included as one of the instructional strategies in the curriculum guide. The second module contains four lesson plans, one on each of instructional strategies stated in the curriculum guide. The third module contains three lesson plans based on the constructivist approach to teaching. Rather than presenting isolated examples of lesson plans from various fields of study, a series of lesson plans within a unit could be presented to provide the teachers with a more holistic understanding of how development of knowledge, skills, attitudes and values can be incorporated into the lessons using multiple teaching methods based on inquiry learning and constructivist approach to learning.

ii. Teachers' competence in science subject matter knowledge

Yip (1998) reported that novice Biology teachers in Hong Kong showed confusion and misunderstandings in a number of basic biological concepts that were required in the Certificate-level Biology Curriculum. Many of these misconceptions were also detected in Certificate-level students. Even experienced teachers demonstrate similar conceptual problems (Barbass 1984; Hashweh, 1987; Tamir, 1991, Sanders, 1993). Yip concluded that there was a high probability of the teachers serving as a direct agent for propagating and reinforcing the incorrect views to their students. It seems obvious that teachers with inadequate conceptual understanding would find difficulty in clearing up children's confusion during science lessons.

If secondary teachers who are graduates in the appropriate discipline were found to have inadequate subject knowledge for teaching the required content of the secondary school curriculum, it is hardly surprising to find that primary teachers who are mainly generalist teachers do not have adequate understanding of the concepts they are teaching. A study carried out by Smith and Neale (1989) on ten elementary teachers about light and shadows revealed that teachers' knowledge was fragmented and often provided evidence of conceptual flaws similar to children's misconceptions. Bennett and Carré's study (1993) found that student teachers had similar misunderstanding as pupils in some areas.

This study revealed that the three teachers who have studied General Science up to school certificate level, had inadequate understandings of subject matter knowledge. The two teachers who have studied Pure Science demonstrated better understandings of the scientific concepts they were teaching. The passing on of misconceptions was clearly illustrated, for example, in the way in which one teacher's misconceptions of whale being a mammal and a fish, and a bat being a mammal and a bird, were clearly propagated to her pupils. The case of the teachers who admitted that their lack of subject matter knowledge caused them not to ask questions to which they did not know the answers, has already been discussed in the section on teachers' teaching practices.

The curriculum module on science concepts (Ministry of Education, Malaysia, 1995a) was aimed at providing teachers with better understanding of science concepts to enable them to teach science more effectively and more confidently. It was pointed out that as the content was written in accordance with the maturity of the teachers, it was not suitable to present the content as such to the pupils. One would infer that this is because the module is meant for the teachers, and therefore, the content in the module would be of a higher level and not be suitable for pupils' consumption. However, if one were to refer to the section on reproduction, this is clearly not the case. All that is said about animal reproduction in the module is: "The ability to produce live ones is one of the characteristics of all living things. Man and mammals reproduce by giving birth. Other animals reproduce by laying eggs" (Ministry of Education, Malaysia, 1995a, p.6). Below the text is a diagram of a cow with its calf and another diagram of a chick hatching from an egg. Does that mean that this is all the subject matter knowledge that teachers need in order to teach the topic effectively? Moreover, the inclusion of five multiple-choice questions for teachers to self-assess their level of understanding on the 'living world' for the entire primary science curriculum covering three full years of study, is definitely inadequate to allow reliable measurement of teachers' competence in these areas. The module also contains a list of English and Bahasa Malaysia references. Due to lack of fluency in English among many teachers, references in English would not be received well with the teachers even if these were made available to them. Reference books in Bahasa Malaysia would have been better reference materials.

iii. Teachers' understanding of pupils' learning

The teachers in this study regarded pupils' intelligence as crucial in determining their capability in science learning. As one teacher said, "If the pupils are bright, they can understand.". All the teachers evaluated their pupils' understanding of the concepts learnt by their ability to answer the exercises in the pupils' workbooks and in the tests and examinations.

The teachers appeared to under-estimate pupils' capabilities to engage in learning in an active and self-directing way. They used this as justification for them not using pupil-centred approach in their lessons. They seemed to think that primary school pupils were totally dependent on their teachers for their learning and therefore teacher explanation became the only source of information. They cited problems of pupils lacking skills for autonomous learning but did not think of strategies teachers could use to help pupils to become more independent learners. One of the teachers seemed to think that these autonomous learning skills would only develop as the pupils grew older, probably when they reached secondary school. Another teacher reiterated the importance of teacher explanation and suggested that activities should be coupled with teacher explanation to help pupils' understanding. She said, "If they watch a video and the teacher does not explain, they will not know".

These teachers seemed to assume that primary pupils were not ready for autonomous learning. They did not seem to be aware of the cognitive apprenticeship learning model where the learning theorists advocate that teachers' scaffolding and guidance need to focus on the zone of proximal development, which refers to the range of knowledge and skills that students are not yet ready to learn on their own but can learn with help from their teachers.

iv Use of resources

Generally the teachers did not use the twelve modules published by the Curriculum Development Centre, with the exception of the Head of Science from the national school who referred to the module on managing resources to "get some ideas about managing the science room". The teachers relied upon limited resources in planning and executing their lessons. They depended primarily on textbooks and the teachers' guide in planning their lessons. The two teachers from the Chinese school found the teachers' guidebook (Khor, 1994b) very clear and useful. They followed the guidebook very closely to ensure that the pupils were getting the main points they ought to get. Following the teachers' guidebook slavishly not only provided them the security that they were in line with the curriculum requirements but would also satisfy the school inspectors. While they spoke well of the teachers' guidebook, one of them expressed her disappointment with the pupils' textbook which contained many pictures but not much information. She said, "I don't know what they expect us to find from the book to tell the pupils.". The three teachers of the other school chose to use a commercial reference book as their reference book. According to the Head of Science in this school, the teachers teaching science had earlier concurred that the pupils' textbook published by the Education Ministry was inadequate in content and decided on a commercially published book to be used as pupils' reference books and that all pupils were required to purchase it. The three teachers frequently referred to this school-adopted reference book rather than the official Education Ministry textbook for their planning of lessons. Raizen and Michelsohn (1994) reported elementary teachers' heavy reliance on science textbooks. They found that the best-selling series textbooks tended to stress an encyclopaedic study of science, emphasising the recall of facts and terms. A well-written textbook can provide a structure from which the elementary teacher can teach science, which Raizen and Michelsohn consider preferable to encouraging individual elementary teachers to develop their own curricula. There is a need for teacher education programs to develop teachers' ability to become wary and critical consumers of the various text series on the market, and to be able to analyse and critique textbooks.

Both schools had a science room. At the time of the study, the science room in one of the schools was still non-operational. The science room in the other school had been set up with the equipment supplied by the state education department. However, teachers reported using the room only rarely. Teachers described themselves as incompetent in the use of equipment such as microscopes and Bunsen burners and therefore did not attempt to use them despite their availability. The libraries of both schools were well stocked with science books and encyclopaedias. Conversation with the teacher-in-charge of the library and library borrowing records revealed that these books were rarely used by the teachers or the pupils. Rather, all of the teachers relied solely on commercial charts as their teaching aids. Although the teachers described lack of resources as a problem, it appeared that their inadequate knowledge of how to use what was available was actually the underlying limitation. Consequently, much of the existing school facilities relevant to science teaching were under-utilised.

v. Lack of professional support

Besides the science orientation in-service courses which three of the teachers had attended, these teachers did not receive any other form of professional support in implementing the new science curriculum either in and out of their schools. School inspectors seemed to focus on evaluating the teachers rather than providing help to the teachers. Science resource teachers who were full time teachers have not been able to make their rounds to the schools due to lack of time and resources. Moreover, the teachers in this study were totally unaware of the availability of these resource teachers or other officers at the district or state levels of the Education Department, who could offer them help in the area of science education.

Various studies have identified key areas of responsibility for curriculum co-ordinators. Basically, all of them indicate that subject co-ordinators should have expertise in their curriculum area, have qualities of leadership, and be enthusiastic for the curriculum area. According to Raper & Stringer (1987 cited in Bell, 1992), the co-ordinator should be a model of competence, enthusiastic, an authority, and possess advisory skills. The Heads of Science in both schools demonstrated lack of competence in some of these areas especially in terms of leadership qualities, enthusiasm and expertise in science teaching methods. Moreover, they were not trained for their job. As such, they were not to be blamed for not being able to play their role effectively. Both the Heads of Science in their respective schools assisted the school administration to hold science meetings which tended to revolve around administrative matters such as updating teachers' record books and setting examination papers. These meetings were devoid of issues which could help them to become better science teachers such as sharing their expertise, developing enrichment and remedial materials, team teaching, peer observation, and other ways to improve pupils' learning. When asked about the expectations of the teachers regarding the role of the head of a subject, one teacher had this to say, "There is not much. You do the planning [scheme of work for the year], conduct a meeting, and record the minutes of the meeting. It is like a formula. Occasionally, the young teachers approach us for help and we will discuss with them".

vi. Lack of organisational support

The Head Teachers of the two schools would have generously considered any request for the purchase of equipment and materials to facilitate science teaching as both schools were in a good financial position with support from the parents and the local business community. This message was conveyed by the Head Teachers as well as the Heads of Science in both schools. However, it appeared that the Heads of Science and the science teachers had not taken up this offer to build up science resources in their respective schools. Both schools had libraries well-resourced with a wide range of books including science books. However, though the audio-visual rooms are well equipped, there was a lack of relevant software such as slides and video tapes.

In one school, where the Head Teacher was seen as the authority figure who was difficult to approach, the teachers and the Head of Science were reluctant to approach her despite the Head Teacher making clear that funds were available to purchase science equipment. Sparks and Loucks-Horsley (1990) stressed the importance of the administrators in exercising good leadership by minimising status differences between their staff members and themselves and promoting informal communication. There seemed to be lack of communication between the Head Teacher and the staff. According to one of the participating teachers, the Head Teacher of this school appeared to want to keep a distance from the teachers.

Probably because of fear of being reprimanded, teachers in this study seemed to do everything possible to ensure minimum noise in the class. Hollon et al. (1991) argued that some tolerance of ambiguity was needed to foster change and encourage teachers' professional development. The National Research Council (1996) also stressed the importance of a climate that permits risk-taking and appropriate distribution of authority to ensure successful professional development of teachers. The Head

Teachers of the two schools in this study, did not create such a conducive climate. There seemed to be a lack of organisational support for teachers to try out different modes of teaching, especially those involving pupils being more active and more noisy.

Both schools emphasised pupils' performance in examination. Teachers had to teach extra classes held in the afternoons, on Saturday mornings, and during the semester holidays. During these classes, pupils practised on answering exam-modelled questions. 'Practice makes perfect' was the clear message to all pupils and that even weak pupils with enough practice would be able to pass the exams. All teachers in this study mentioned repetition and reinforcement as vital to facilitate pupils' learning, a teaching and learning tradition that is not supportive of pupil participation and inquiry (King, 1989).

Parents put considerable pressure on the school to prepare students for national examinations. Teachers are sensitive to pressures from the pupils' parents and the head teachers. The head teachers in turn were subjected to the pressure from the education department. The teachers' priority is in getting pupils to get good marks as desired by the Head Teacher and the parents rather than thinking of how to help pupils to become thinking individuals as advocated in the curriculum. As commented by one teacher, "Marks is the reality. ... They [the parents] are not concerned with what their children have actually learned. The aim is to get good results. They do not care about methods, even if it is learning by rote".

Administrators of both schools seemed to hold a greater concern for the smooth operation of the school than they did for the types of learning that occurred in the classrooms. They stressed the importance of pupils' high performance in the national assessment by enforcing compulsory extra classes for pupils to practise exam-type questions. The Head Teacher of one school suggested that the teachers should follow the book closely to avoid making mistakes. The message was conveyed by the science head to the other teachers in the science meeting at the beginning of the year. The two case study teachers in that school seemed to be doing that.

Though pressure is often regarded as a negative factor, successful change always includes elements of both support and pressure (Fullan, 1991). According to Fullan, "Pressure without support leads to resistance and alienation; support without pressure leads to drift or waste of resources (p. 91). In this study, teachers and school administrators seemed happy with teacher-dominated classroom interactions. Teachers were not under pressure to change or modify their way of teaching as long as their pupils' performance lived up to the standard expected of parents and head teachers. They continued to use the didactic approach in their science teaching. Perhaps, the change to something unfamiliar may lead to unknown consequences which may be undesirable. Getting pupils to bring animals to the class might create too much excitement among pupils resulting in 'chaotic' situation with high noise level, a situation often seen as undesirable among the head teachers and other teachers.

The school culture in this study, engenders a teaching role consistent with the expectations of students, other teachers, and school administrators (Briscoe, 1991 cited in Aubusson, 1994). A noisy classroom is seen as one where the teacher cannot control the class and a non-conducive climate for learning, whereas a silent class is seen as not only providing a conducive environment for learning but pupils are also presumed to be fully cognitively engaged. Such view tends to cause teachers to avoid the use of inquiry approach in their teaching, and needs to be re-examined in terms of the development in cognitive learning theories.

7.1.5 The extent to which the teachers implemented the Malaysian Primary Science Curriculum

The extent to which the Malaysian primary science curriculum has been implemented can be clearly seen by comparing the curriculum emphasis and the teachers' classroom practices as summarised in Table 7.3. All observed lessons emphasised the teaching of knowledge, providing pupils with little opportunity for learning of science process skills, manipulative skills, thinking skills, scientific attitudes and moral values. While the mandated curriculum is inquiry-based, the implemented curriculum in these classrooms revealed little evidence of the inquiry approach. Teacher explanation with the help of charts dominated the lessons on animal reproduction instead of providing the pupils with first hand experience of observing the development of these animals by keeping them under suitable conditions. Activities such as scrap books and charts making were included because they were mentioned in the curriculum materials rather than for what they could contribute to the pupils' learning process. Teacher-made tests and examinations also focus on testing knowledge which reinforces the emphasis on knowledge acquisition as the main goal of science education. For the five case study teachers, the mandated curriculum has yet to be implemented. Their teaching practices are at odds with the kind of teaching that an inquiry-based science curriculum strives to achieve.

Table 7.3: Comparing Malaysian Primary Science Curriculum Emphasis and Classroom Practice

Malaysian Primary Science Curriculum Emphasis	Classroom Practice
Emphasis on knowledge acquisition, development of scientific skills and thinking skill, and development of scientific attitudes and moral values	Emphasis solely on knowledge acquisition and little on development of skills, attitudes and values
Encourage inquiry approach involving hands-on and minds-on activities	Teacher explanation as the main instructional strategy
Responding to individual pupil's interests, strengths, experiences, and needs	Treating all pupils alike and responding to the group as a whole
Focusing on pupil understanding	Focusing on pupils acquisition of information to perform well in examinations
Sharing of responsibility for learning with pupils	The only effective way for pupils to learn is to listen to the teacher. Primary school pupils are not mature enough to learn on their own
Encourage multiple instructional strategies to develop a wide range of skills	Frequent use of teacher explanations and questions and answers sessions, and little use of other instructional strategies
Emphasis on understanding of key ideas	Covering many examples
Learning subject matter in the context of technology, and its relevance to pupils' daily lives	Learning subject matter for passing the exam
Use of resource materials which can provide first hand experience for pupils	Use of charts as the main resource materials as they are the most readily available
Assessment of knowledge, skills, attitudes and values by advocating the use of a more valid instrument for assessment including written test, observation and practical tests	Only written tests administered while no observation and practical tests were conducted
Emphasis on higher cognitive skills such as interpretation and reasoning rather than on regurgitation of scientific facts	Most items in tests and exam test pupils' ability to regurgitate factual knowledge and few questions test pupils' higher cognitive skills
Encourage pupils' ongoing assessment to diagnose their weaknesses and strengths	Assessment for grading pupils' performance, summative assessment

Despite a series of curriculum reforms in the past three decades, elementary science teaching in many countries remains disappointing. Even in the United States where significant steps have been taken at the national, state, and local levels to improve science education, Raizen and Michelsohn (1994) reported the undesirable state of elementary science instruction in schools all over the country. They described instruction focusing on factual information that was disconnected from experience and concept development, with few opportunities provided for exploration and discovery, for developing analytical skills, or for relating science to other disciplines to foster an integrated understanding of the world. Teachers relied heavily on textbooks (Weiss, 1987 cited in Raizen & Michelsohn, 1994), and traditional approaches emphasising rote learning and content coverage at the expense of learning with understanding continue to persist in many of today's elementary science classrooms (Tobin et al., 1990). "Transmission of non-constructed knowledge (factual information) was the almost exclusive focus in many science classrooms, and memorisation and recitation was typical" (Prather, 1993, p.63).

7.2 Summary

The findings of this study reveal that there exists a wide disparity between what is intended by the developers of the Malaysian Primary Science Curriculum and how the curriculum was actually implemented in the classrooms. This can be seen in terms of the teachers' use of instructional strategies, their questioning techniques, their use of resources, and their attitudes towards pupils' prior knowledge. There was no attempt to use a wide range of instructional strategies to enable the pupils to develop the various skills and attitudes ot to gain meaningful understanding of the various science concepts. Teacher explanation was the main teaching strategy used and was confined to transmitting factual information to the pupils. The majority of the questions interspersed teacher explanation, were of low-cognitive nature. When higher cognitive questions were asked, teachers were unable to stimulate pupils' thinking processes due to their lack of skills in effective questioning. Hands-on activities were rare, and if used, were largely restricted to making or drawing charts, with no due consideration to incorporate pupils' cognitive participation.

Teachers rarely provided the pupils with concrete and realistic experiences. None of the teachers used any animal specimens to teach animal reproduction despite being readily available. Instead, commercial and teacher-drawn charts were the main teaching aids used. When slides and videotapes were used, pupils merely watched the slides and videotapes and listened to teacher explanation. Both teachers and pupils depended primarily on textbooks while other relevant books and encyclopaedias in the school library were rarely used. Though these teachers seemed to realise that pupils had relevant experiences and prior knowledge regarding the concepts being taught, they did not seem to regard these as important bases upon which to develop pupils' understanding of these concepts.

The teachers in this study did not seem to have adequate understanding of the emphasis of the Malaysian Primary Science Curriculum. The orientation courses and the curriculum materials seemed to have offered little help to these teachers to implement the curriculum as required. This was the case with the three National School teachers who had attended the courses and had access to the curriculum materials, and yet did not show better understanding of the curriculum than the Chinese School teachers who did not attend any of the courses and did not have access to all the curriculum materials. The case study teachers' conceptions of science teaching-learning and their understandings of instructional strategies, tended to promote rote learning which was in conflict with the inquiry learning advocated in the new curriculum. The school administrators and parents did not provide any pressure for them to change their mode of instruction. Consequently, the teachers succumb to the pressure to get through the curriculum and prepare the pupils for examinations using the traditional instructional strategies they know best.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

Chapter Eight presents the conclusions of the study which focus on identifying the factors found to have influenced the implementation of the Malaysian Primary Science Curriculum. Recommendations are offered to improve the success of the curriculum implementation process. Limitations of the study are discussed and avenues for future research are explored.

8.1 Factors Influencing Curriculum Implementation

This study set out to explore five experienced primary teachers' attempts to teach an inquiry-based science curriculum. If the success of the new Malaysian Primary Science Curriculum is to be measured by the present assessment system, there is little to worry about as these teachers, despite their non-inquiry mode of teaching, are continuing to ensure high performance of their pupils in the national assessment. Indeed, the researcher was told by the Head Teachers of the two schools involved in this study, that the pupils did very well in Science in the 1997 UPSR examination. However, there needs to be much more concern if one examines the gap between the actual classroom practices and the curriculum intent. From the later point of view, it can be concluded that these teachers had not implemented the curriculum as intended by the curriculum developers.

All the case study teachers emphasised coverage of factual knowledge in their lessons while application, analysis, synthesis, and evaluation of such knowledge were conspicuously absent. There was little evidence of the integration of scientific skills, thinking skills, scientific attitudes and moral values in their lessons. They tended to concentrate on preparing pupils to answer examination questions rather than emphasising on pupils' conceptual understanding. Their teaching practice can be explained by the combination of various factors. Teachers' and head teachers' concerns for pupils' performance in examinations, parental pressure, management problems, content coverage, teachers' beliefs about how pupils learned science, and their limited knowledge on the nature of science, science teaching and the curriculum emphases, have contributed to the teachers succumbing to the traditional method of teaching. These factors are discussed under four categories: (i) teacher preparation, (ii) curriculum documents, (iii) assessment system, and (iv) support system.

8.1.1 Teachers' preparation

All five teachers, including those three who had attended at least one of the three in-service courses, lacked proper and adequate understanding of the various aspects of the curriculum. Due to this lack of knowledge and understanding, these teachers were not able to maximise the use of the available resources either to acquire meaningful understanding of the scientific concepts, or to develop the whole range of skills and values among their pupils. It also jeopardised their ability to maximise learning potentials of the various activities carried out in their lessons. These teachers were not able to act as role models for pupils to develop these skills and values.

The in-service courses had not provided the teachers with the knowledge and skills to enable them to implement the curriculum as required. Though the content of the courses was relevant, the time constraints impeded the effectiveness of these courses. The activity-based approach adopted is a positive step toward meeting the needs of the teachers. However lack of appropriate modelling and guided practice, and lack of consideration of teachers' preconceptions have rendered the courses less effective than they might otherwise be.

The teachers used a lot of questions to involve more active participation among pupils in their lessons. However, the types of questions asked and the approach used in dealing with pupils' responses, revealed these teachers' lack of understanding in the area of effective questioning techniques.

Teachers did not use existing resources in the schools, educational television programs, and the availability of other resources in the resource centres nearest to them. The existing curriculum materials did not seem to offer the teachers much help. Some teachers turn to the help of commercial textbooks which merely offer factual information on topics covered in the curriculum. Teachers were clearly asking for resources which they could use virtually off the shelf and slot into relevant places in present science curriculum. Unfortunately, such resources were scarce.

With no proper understanding of the new curriculum, teachers used what they themselves referred to as "their own methods" to teach, which were mainly based on their own science learning experiences during their school days. Teachers felt ill-prepared for anything other than teacher-directed learning styles. Their positivistic view of science may also be a significant disposition leading them to adopt a transmissive approach to science teaching. Moreover, these methods seemed to enable them to manage their lessons in an orderly and quiet manner which was considered to be conducive to pupils' learning. These teachers perceived that the use of practical activities as advocated in the inquiry approach could present considerably more organisational problems than the lecture-based teaching approach. They were convinced that their existing science teaching practices could yield the expected academic results, as far as the achievement of good grades was concerned. Hence, they did not see the need to change their way of teaching.

8.1.2 Curriculum materials

The mandated curriculum as contained in the syllabus guide, advocates the importance of content knowledge, scientific skills, thinking skills, scientific attitudes and moral values, and encourages an inquiry approach. However, the Ministry published textbooks and teachers' guides fail to incorporate significant features of the curriculum policy or goals. They do not provide clear guidelines on how scientific skills, scientific attitudes and moral values could be integrated in the lessons. Many of the suggested activities in these curriculum documents are not in line with the inquiry approach. The Chinese school teachers adhered closely to the suggested activities in the Chinese version of the teacher's guide as it contained clear step-by-step instructions which were easy for the teachers to follow. The three National school teachers who did not find the Bahasa Malaysia version of the teachers' guide useful, resorted to the use of a commercial textbook which contains subject content knowledge and little else. The teachers did not make use of the twelve curriculum modules. These materials did not appeal to the teachers as they were not well designed. In addition, distribution and accessibility of the curriculum materials is another problem.

8.1.3 Assessment system

The over-emphasis on the importance of good examination results by the society, has created a system which is so exam-oriented that it does not give much attention to the overall development of a pupil. The teachers in the study used assessment primarily for accountability where scores and grades were assigned for all pupils. The assessment emphasised recall of factual information. As these teachers wanted their pupils to do well on such assessments, they shaped the nature of instruction so that much of their science teaching focused on definitions of terms, verbal explanations and repetitions. Thus, teaching-learning strategies and examination system in Malaysian classrooms militate against active pupils' participation and inquiry.

There is a need to redefine expectations of student achievement by students themselves, by parents, by teachers, and by the public. Questions need to be raised concerning the social pressure acting on teachers to teach towards examinations and the problem of inculcating independent and critical thinking in a cultural context, where both teachers and pupils are more used to unquestioned acceptance of authority (Lee, 1992). King (1989) argued that once a teaching and learning style has become embedded in a society, it has a resilience that is almost independent of changes in government, major curricular reforms or even changes in teacher training. Reform efforts need to be targeted at all subjects, not just science.

8.1.4 Support system

Teachers of the two schools in this study, lacked both the professional support and the organisational support necessary for the successful implementation of the new curriculum. The science heads of the schools were unable to play their role effectively as curriculum co-ordinators as they had not been trained for the job. This lack of progressive leadership within the schools and the districts contributed to the practically non-existence of any form of school-based professional development for the teachers. Consequently, these teachers conformed to each other's non-inquiry mode of teaching practice.

Though both schools have been generous in providing the basic physical facilities and teaching resources, there was no support to encourage the teachers to make use of these resources in their lessons. The school administrators were more concerned with the smooth running of the school and the pupils' performance in examinations. They did not express similar concern about the teaching-learning processes happening in the classrooms. In fact, they encouraged the teachers to use the traditional drill and practice method, working through plenty of exam-type questions to improve pupils' examination performance.

8.2 Contributions of the Study to the Literature

8.2.1 Research methodology

As mentioned earlier in Chapter Three, EPRD and School Inspectorate Reports had reported the status of implementation of the Malaysian Primary Science Curriculum. The research methodology as reported in the EPRD study included both a nationwide survey and case studies of 14 schools, two schools each from seven of the thirteen states in the country. However, the findings of the EPRD study were largely based on the nationwide survey while little was published on the case studies. The School Inspectorate Reports were largely based on school inspectors' observations of teachers' lessons, and their inspection of the physical facilities in the schools. While the School Inspectorate Reports describe an overall picture of teachers' classroom practice and the availability of the physical resources in the schools, they do not provide much insight into the possible causes leading to teachers' behaviour in implementing the curriculum.

The findings of the present study confirms the unsatisfactory state of implementation of the Malaysian Primary Science Curriculum as reported in the two studies described in the preceding paragraph. The case study approach used in this study enables the researcher to explore teachers' understanding and knowledge on various aspects of science and science teaching. Consequently, teachers' needs and problems can be more easily identified. This will facilitate the policy makers and teacher educators to plan appropriate strategies to rectify the various problems faced by the teachers in the implementation of the said curriculum.

8.2.2 Factors influencing curriculum implementation

The findings and conclusions of the study in relation to the factors affecting curriculum implementation as described in Sections 7.1 and 8.1 indicate that they are similar to those found in the Western literature. However, in addition, the findings of this study reveal that failure to appreciate the cultural context of learning by simply adopting Western models of inquiry learning in Malaysian classrooms, seems to be particularly problematic in the implementation of the Malaysian Primary Science Curriculum. There lies the problem of inculcating independent and critical thinking, in a cultural context where many education administrators, teacher educators, teachers, head teachers, pupils and parents are used to unquestioned acceptance of authority. In Malaysian culture, like those of other traditional societies, it is conformity rather than ingenuity and creativity that is of highest social value. In the classrooms where the focus is on quantity of learning rather than quality of learning, the teachers' main task is to transmit a body of static knowledge in the form of factual information to their students. Teaching students to think for themselves is seen as questioning the expertise and knowledge of elders and teachers. All these appear to be in conflict with the inquiry mode of teaching and learning, in which pupils are encouraged to question teachers' assertions and test the validity of statements for themselves.

Two decades ago, Seng (1979, in Baimba, 1992) reported of studies which revealed that Southeast Asian students found the easiest way of learning science and mathematics was by 'listening'. These students found learning by 'doing' interesting but demanding and difficult, and learning by 'talking' the hardest of all. The findings of the present study confirm that this situation continues to exist in today's Malaysian classrooms. This is because pupils' learning orientation is strongly influenced by teachers' teaching orientation. The teaching methods used by the teachers in this study would have contributed much to the students' orientation of learning by listening to the teachers rather than by doing and talking as in discussing.

8.3 Recommendations for More Effective Curriculum Implementation

Teachers were asked to implement a curriculum which they knew little about. Some of them did not have the opportunity to attend the relevant courses. For those who did attend the courses, these courses had not been very effective in helping them to better understand the curriculum. The teachers did not find the curriculum materials helpful. The assessment system and the social expectation of their role did not put any pressure on them to change their way of teaching. Therefore, these teachers continued teaching in the ways that were familiar to them without thinking seriously about what the curriculum advocated. The problems impeding the successful implementation of the curriculum will not go away on their own. Immediate actions need to be taken to remedy the situation. In accordance with the findings of the study, the following recommendations are proposed.

8.3.1 Review of teacher preparation programs

The findings of this study have revealed that teachers lacked understanding in a number of areas such as subject matter knowledge, general pedagogical knowledge, questioning techniques, use of resources, science teaching and learning, and curriculum knowledge. The in-service courses for the teachers did not seem to be effective in providing the teachers with the understanding and skills necessary to implement the primary science curriculum. The pros and cons of these courses have already been discussed. The main weakness of these courses seemed to be the emphasis of breadth of coverage at the expense of depth of topic development. This has resulted in the teachers being exposed to a lot of ideas without proper understanding of any of them. The following recommendations are made to improve the effectiveness of teacher preparation programs, which include both pre-service and in-service courses.

1. Reduce the number of activities on the important aspects of the curriculum. This is to ensure that there is enough time for student teachers and teachers to participate in the activities both physically and cognitively. Each important aspect of the curriculum has to be dealt with in-depth to enable them to understand it well before they could apply it in their teaching. For this to occur, teachers need to have the first-hand experience in carrying out the activities, followed by discussion and reflection on these activities.

2. Provide opportunities for student teachers and teachers to make their views explicit, to discuss and analyse these views critically, and to compare their views with those found in the literature. Teacher preparation programs should address the participants' preconceptions on the various aspects of science teaching and learning.

3. Emphasise development of effective and varied questioning techniques. As there is a tendency among teachers to ask a lot of questions in their lessons, it is necessary that they have proper knowledge and understanding of effective questioning techniques, and the use of various types of questions, especially the higher-order cognitive questions.

4. Provide role models in inquiry learning to the student teachers and teachers. They need to be provided with appropriate modelling and guided practice to enable them to use inquiry approach in their lessons. This can be facilitated by teacher educators who have the required expertise to act as role models for the student teachers or teachers in inquiry learning. Exemplary practising teachers or videotapes of lesson exemplars are alternative resources.

5. Courses should be relevant to the facilities available at the schools. Providing the schools with materials and equipment is essential but not enough to ensure that the teachers use them effectively in their lessons. The findings of this study revealed that the study case teachers did not make full use of the many existing resources available in the schools. Since all the schools in the country have been provided with standard science equipment and materials, it is suggested that student teachers and teachers should be taught how to use them effectively in their lessons.

6. Student teachers and teachers should be trained to use other existing resources in the school, such as books, and national television education programs. These resources are available in most schools throughout the

country. They should also be encouraged to the use of plant and animal specimens, and other materials which are readily available in the local environment. This can be done by involving them in obtaining the plant and animal specimens, keeping them, and doing various activities related to the primary science curriculum.

7. Teacher educators must have the necessary expertise if they are to be effective in the delivery of such program. The quality of any teacher preparation program very much depends on the quality of the trainers involved in the program.

It is hoped that with such experiences, student teachers and teachers would be able to see for themselves that the move towards inquiry approach can be achieved without sacrificing examination efficiency when compared with the traditional transmission-oriented approach. This is important for curriculum reform efforts in an achievement-oriented environment such as that of the Malaysian society. Moreover, they could also see the many other positive outcomes of such an approach. When teachers see that a new program or practice enhances the learning of their students, it is likely that they will change their beliefs and attitudes in a significant way.

8.3.2 Review of ongoing professional support for teachers

The findings of the study show that while both schools seemed to offer support in terms of purchasing science materials and equipment, little professional support was available to the teachers. There is a need for professional support both within and outside of the school. The following recommendations are made to provide the support required by the teachers, to ensure more effective implemention of the Malaysian Primary Science Curriculum.

1. Heads of Science in the schools should be provided with appropriate training to equip themselves with the necessary leadership qualities as well as expertise in science and science teaching so that they can be more effective in playing their role as subject co-ordinator in working with the other teachers in the school.

2. Time and resources should be made available for teachers' professional development. Teachers should be encouraged to read journals and books to keep them up to date with recent development in science education. One

possible way would be to get teachers to read a journal article or a section of a book relevant to science education. This can be followed up by inviting them to a reading group where they could discuss and reflect the issues raised from their reading, and relate them to their teaching. Teachers can also be encouraged to hold deliberate conversations with colleagues to share, reflect and learn from each other's experience.

3. Professional support outside of school and within a district should be made available to the teachers. The science resource persons, who were full time teachers themselves, were found to be unable to play this role effectively. Full time personnel with expertise in the primary science curriculum can be made in charge of the schools within a district. Besides providing immediate assistance to the teachers, this person can organise a series of one-day workshops for the science teachers to share their experiences and to gain better understanding on the problematic areas. Providing such support during the implementation process is crucial in helping the teachers to overcome their many uncertainties and anxieties, especially at the initial stage of implementation.

4. Head teachers should be introduced to the requirements of the curriculum. This is to enable them to understand the need for the teachers to adopt a broad range of instructional strategies to achieve the various objectives found in the curriculum, and be more tolerant of noise and management problems associated with inquired-based learning in the classrooms.

8.3.3 Review of assessment system

Presently, there is little reward for changing teaching strategies and classroom organisation to emphasise high-level cognitive learning and problem solving if school and national assessments continue to evaluate the recall of facts and other low cognitive skills. A change in the assessment system where evaluative instruments value higher cognitive skills, might put some pressure on the teachers to plan more meaningful and thought-provoking activities, thus creating a more conducive atmosphere to inquiry and problem solving in their classrooms.

1. Assessment needs to be in line with curriculum emphasis. Alternative approaches to assessment that provide valid and reliable information on the understandings of the knowledge and skills as espoused in the curriculum must be developed.

2. UPSR-type practical assessment for evaluating scientific skills and manipulative skills should not be restricted to primary six pupils only. Similar assessment should be extended to primary four and primary five pupils.

8.3.4 Review and revision of curriculum materials

The strengths and weaknesses of Malaysian Primary Science curriculum materials have already been discussed. Generally, the teachers in the study did not speak favourably of the curriculum materials published by the Ministry of Education. There is a need to review and revise these materials to ensure that they are in line with the curriculum requirements. These materials need to be easily comprehensible to the teachers so that they can be translated into classroom action.

1. A compilation of inquiry-based lesson exemplars on each of the topics from the curriculum should be developed. These lesson exemplars should include the use of equipment and materials readily available to the teachers. They should include explicit statements of desired pupil outcomes that give attention to science process skills, the nature of scientific inquiry, and to attitudes and values.

2. Videotapes of lesson exemplars based on a broad range of activities should be produced to help teacher educators, resource teachers, and teachers to conduct various teacher preparation courses and in-house training courses.

3. These materials described in (1) and (2) need to be field-tested, evaluated and refined.

4. In areas where there is lack of expertise, time and money, those involved in the development of these materials should look into the feasibility of modifying and adapting foreign well-researched materials with similar philosophical underpinnings for the Malaysian contexts. This is because well designed curriculum materials require expertise of teachers, curriculum developers, scientists, learning theorists, and publishers.

5. All curriculum materials should be available in Bahasa Malaysia, Chinese, and Tamil.

6. These materials should be made available to all teacher educators, resource teachers, and teachers who are involved in the implementation of the primary science curriculum.

8.4 Limitations of the Study

The main weakness of this study lies with the problem of generalizability of the findings due to the smallness of the sample, a weakness inherent in the case study approach. This study was carried out with experienced teachers in an urban setting. Teachers in rural settings are likely to face different types of problems, and so is the case with less experienced teachers. Besides, the findings of this study are based on observation of lessons from only one field of study, which is the 'Living World'. It is therefore important for the readers to realise that though the findings and conclusions from this study might be able to enlighten them on teachers' problems and needs in similar situations, these findings and conclusions do not represent a holistic picture of the status of implementation of the entire primary science curriculum across the schools in the country. It is recommended that more research need to be done to gain a more holistic picture of the status of implementation of the said curriculum. These are described in the following section.

8.5 Recommendations for Future Research

The findings of this study revealed considerable discrepancies between what was intended by the developers of the Malaysian Primary Science Curriculum and how the curriculum was actually implemented in the classrooms of five teachers in two schools. The teaching practices of these teachers were found to be incongruent with the inquiry learning advocated by the curriculum developers. The study highlighted a number of factors which could have contributed to the teachers' non-conformity to the curriculum intent. There is little doubt that there are science teachers, out there somewhere, who promote inquiry learning in their classrooms. It is important to carry out studies on these teachers who can serve as role models for inquiry teaching. The findings of such studies could provide us with a better understanding of the positive factors which enable these teachers to use an inquiry approach in their teaching. An understanding of these factors could facilitate the policy makers to take into considerations such factors in the future planning of strategies to ensure successful implementation of the curriculum.

As indicated in the preceding section on the limitations of the study, this study was carried out with experienced teachers in urban settings. More case studies need to be conducted with more teachers working in different settings, to gain a more holistic understanding of the factors affecting the implementation of the Malaysian Primary Science Curriculum. Therefore, similar studies should be carried out with teachers working in different contexts, such as in smaller schools in rural settings, and with less experienced teachers.

The present study is based on the classroom observations of teachers teaching 'Animal Reproduction' from the 'Living World'. It is recommended that similar studies can be carried out based on classroom observations of these teachers teaching units from the other fields of study in the curriculum. All the teachers in this study described themselves as being familiar with the 'Living World' while they expressed their concerns over 'Planet Earth and Beyond' and the 'World of Technology'. As such, they were likely to face different kinds of problems in teaching the less familiar concepts from these fields of study.

Now that the researcher has gained some insight into some of the problems faced by the teachers in implementing the inquiry-based science curriculum, appropriate interventions could be planned and introduced to the teachers so that they can acquire the appropriate knowledge, skills and experience in adopting an inquiry approach in science teaching. The effects of such interventions could be studied to develop more effective ways of providing teachers with the knowledge and understanding necessary to practise inquiry teaching in science classrooms.

As mentioned earlier, the quality of any teacher preparation programs very much depends on the quality of the trainers involved in the programs. It would be beneficial to investigate the teaching practice of the teacher educators in preparing pre-service and in-service teachers to implement the inquiry-based science curriculum.

8.6 Concluding Note

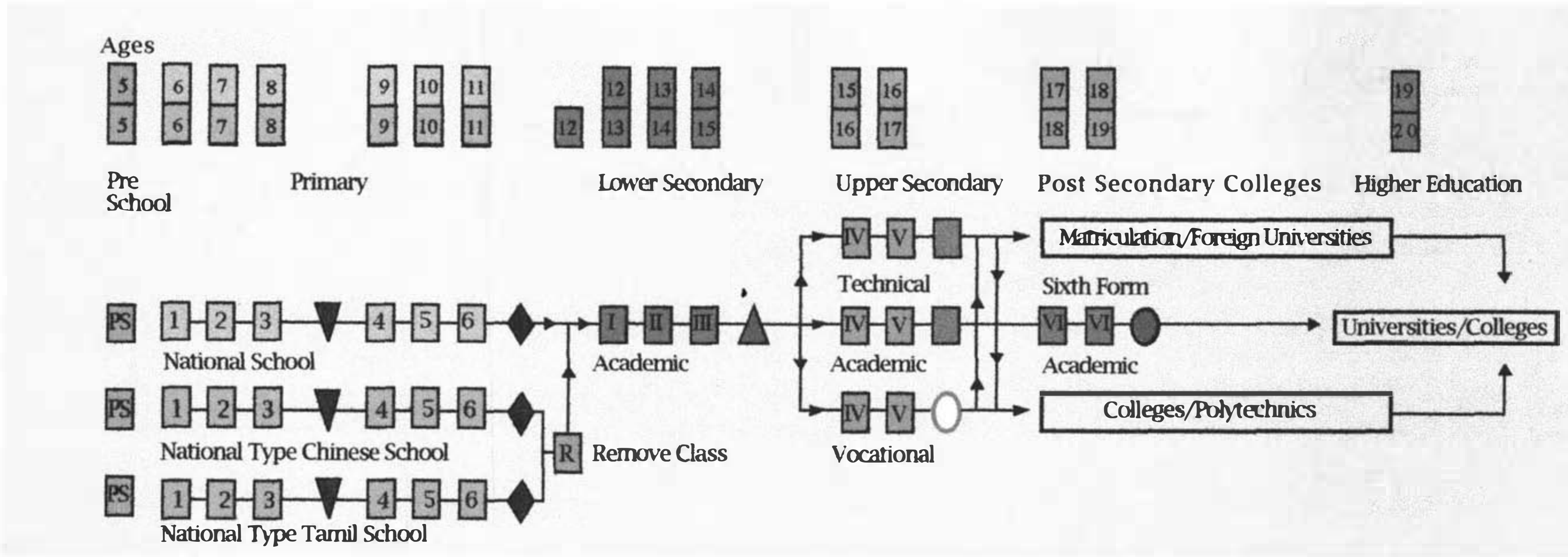
It would be easy to list of ills of the implementation of the primary science curriculum by the five experienced teachers in the study and paint a overly pessimistic picture of what is happening in Malaysian primary science classrooms. Despite being experienced and well thought of, these teachers were ill-prepared and lacked proper understanding of the curriculum. Existing curriculum materials lacked clarity and relevance to the teachers. Available resources were under-utilised. Tests and examinations encouraged regurgitation of facts with little emphasis on higher levels of thinking, and there was considerable societal pressure for students to perform well in these tests and examinations. A vision that will transform teachers from people who merely pass on some else's knowledge to creative facilitators of children's learning through involvement in the process of science investigation, is crucial in ensuring the successful implementation of the inquiry-based science curriculum. Numerous problems will have to be solved on the way to achieve this vision and there are no quick fix solutions to these problems. However, the case study teachers' openness in sharing their knowledge, their keenness in wanting to listen and learn new ideas, and their genuine interest and commitment in wanting to improve their pupils' performances, provide optimism that these teachers will be able to implement the espoused curriculum if they are provided with appropriate training and support.

The Malaysian Primary Science Curriculum is in line with contemporary international science education literature, envisioning the science classroom as a centre of intellectual inquiry where teachers and pupils engage in exploring scientific ideas. It is important that we as science educators ensure that this inquiry-based science education is being implemented successfully in the classrooms for the benefits of future generations. It is in the elementary school years that teachers have ample opportunity to cultivate and nourish their pupils' innate curiosity about the world in which they live. Well-taught science classes should not only provide pupils with meaningful understanding of the world, but should also help them to develop the skills, attitudes and values to investigate problems logically and systematically, and to make informed decisions based on evidence. The foundation built at this young age is the bedrock on which more knowledge and understanding of science can be constructed at later stages. There is a local proverb which says, 'Melentur buluh, biar dari rebungnya' which means if you want to shape the bamboo, you have to do it while it is still young. It is the responsibility of all who are involved in science education to ensure that each one plays his or her role effectively to help educate Malaysian pupils to equip them with the necessary knowledge, skills, attitudes and values to become self-reliant, creative and critical individuals who can help the nation to achieve its 'Vision 2020' in becoming a fully industrialised nation in the near future.

GLOSSARY OF ACRONYMS

EPRD	Educational Planning and Research Division
KBSR	Integrated Primary School Curriculum (Kurikulum Bersepadu Sekolah Rendah)
PEKA	Practical Test Assessment (Penilaian Kerja Amali)
PMR	Lower Secondary Assessment (Penilaian Menengah Rendah)
PPK	Curriculum Development Centre (Pusat Perkembangan Kurikulum)
PTS	Level One Assessment (Penilaian Tahap Satu)
SK / SRK	National Primary School (Sekolah Kebangsaan / Sekolah Rendah Kebangsaan)
SPM	Malaysian Certificate of Education (Sijil Pelajaran Malaysia)
SRJK (C)	National-Type Chinese School (Sekolah Rendah Jenis Kebangsaan - Cina)
SRJK(T)	National-Type Tamil School (Sekolah Rendah Jenis Kebangsaan - Tamil)
STPM	Malaysian Higher School Certificate (Sijil Tinggi Pelajaran Malaysia)
UPSR	Primary School Performance Test (Ujian Prestasi Sekolah Rendah)

Appendix A
The Education System in Malaysia



PRIMARY LEVEL

National Schools

- Bahasa Malaysia as the medium of instruction
- English is a compulsory subject
- Mandarin, Tamil and indigenous languages are made available
- Islamic/Moral Education

National-type Schools

- Mandarin or Tamil as medium of instruction
- Bahasa Malaysia and English are compulsory subjects
- Islamic/Moral Education

Curriculum Guidelines by the Ministry of Education focus on :

- Mastery of 3Rs
- Values across the curriculum
- Thinking Skills
- Pre-vocational skills
- Basic science concepts
- Art and recreation
- Co-curricular activities

(*Source: Internet website: http://www.moe.gov.my*)

SECONDARY LEVEL

Academic Schools

- Offer general education and courses in the arts and science streams
- Vocational and technical subjects are incorporated into the curriculum

National Religious Schools

- Offer general education, academic subjects
- Compulsory courses in:
  Arabic language (Advanced)
  Islamic Tasawwur Al-Quran and As-Sunnah Education
  Islamic Syari'ah Education

Technical Schools

- Offer general education and technical & vocational based subjects
- Prepare students for entry into technological, vocational & science related courses at the diploma and degree levels

Vocational Schools

- Offer general education and basic vocational skills
- Courses are in two streams - vocational education stream and skills training stream

POST-SECONDARY LEVEL

Matriculation Programmes

- One to two year programme
- Meets requirements for entry to local universities
- Conducted by colleges and some local universities

Malaysian Higher School Certificate

- Two year programme
- Offer academic/technical and religious subjects
- Conducted in selected schools and colleges

Certificate Programme

- One to two year programme
- Training for a vocation
- Offered by polytechnics and colleges

Diploma Programmes

- Two to four year programme
- Training for a vocation or further study
- Offered by polytechnics and colleges

ASSESSMENT IN THE NATIONAL EDUCATION SYSTEM

- Continued school based assessment at all levels
- Common public examinations

▼ Level One Assessment (PTS)

◆ Primary School Assessment Test (UPSR)

▲ Lower Secondary Assessment (PMR)

■ Malaysian Certificate of Education (SPM)

○ Malaysian Certificate of Education (Vocational) (SPMV)

● Malaysian Higher School Certificate (STPM)

Appendix B
Initiation Activities in the Implementation of Malaysian Primary Science Curriculum

Year	Activities
1993	Planning and formulating the curriculum Planning and formulating the science curriculum for pre-service student teachers
1994/1995	Preparation of curriculum materials for teachers and pupils Preparation of supporting materials for teaching-learning Preparation of training packages for orientation courses for teachers Conducting orientation courses for resource teachers Managing evaluation for pupils Implementation of curriculum at Primary Four level Planning of science laboratories Provision of science equipment and materials
1995/1996	Monitoring and evaluating teaching-learning Implementation of curriculum at Primary Five level
1996/1997	Implementation of curriculum at Primary Six level

(Source: Ministry of Education, Malaysia, 1993d, p.33)

Appendix C
Content of the Twelve Modules on Malaysian Primary Science Curriculum

Module	Content
Module 1: About science	What is science? Historical development of science. Scientific method. Scientific attitudes and ethics. Science, technology and society.
Module 2: Scientific skills	Science process skills; manipulative skills.
Module 3: Thinking skills	Critical thinking. Creative thinking.
Module 4: Scientific attitudes and moral values	Indicators of scientific attitudes and moral values.
Module 5: Teaching-learning strategies (I)	How pupils learn science and their implications on teaching. Questioning techniques. Experiments; discussions; simulations.
Module 6: Science concepts	Descriptions of various science concepts in the five fields of study.
Module 7:: Evaluation (I)	Observation; oral; written; practical.
Module 8: Teaching-learning strategies (II)	Lesson plans on i. experiment ii. simulation iii. project iv. field work
Module 9: Management of primary school teaching-learning resources	1. Management of science room: i. Stock book, breakage book, loan book; ordering of materials and equipment; payment. ii. Maintenance and storage of equipment and materials. iii. Animals and plants specimen preservation iv. safety. 2. Management of science garden: ponds, nursery, vegetable garden, hydroponics garden, mini-zoo, rock garden, weather station, investigation corner. 3. Teaching aids.
Module 10: Evaluation (II)	Evaluating scientific skills and thinking skills.
Module 11: Operationalising process skills in teaching-learning	Examples of observing, classifying, measuring and using numbers, inferring, predicting, communicating, using time-space relationship, interpreting information, defining operationally, controlling variables and experimenting.
Module 12: Teaching-learning strategies (III)	Learning through constructivist approach. Examples from Earth and the Universe, Material world and Physical world.

Appendix D1
Head Teacher's Interview

Researcher: I am interested in the implementation of the new science curriculum and wish to understand the approach and support the school is able to provide the teachers. Can you answer a few questions for me?

1. This is the third year KBSR science has been implemented. What are the successes and problems the school and the science teachers face in implementing this programme?

2. To what extent has the administration of the school been supportive to the needs of the science teachers ?

3. What type of support would you like to provide the science teachers to implement the KBSR science programme more effectively?

4. What are the constraints that you face in providing such support?

5. How are the science teachers chosen?

6. How often do you observe what is going on in class?

7. What do you see as some of the characteristics of a good science teacher?

8. How is the workload of science teachers compared to other teachers?

9. How much grant did you spend on buying materials and equipment required for science teaching?

10. What are the sources of the grant?

11. Do you believe that the school provides enough resources for the science teachers?

Appendix D2
Teacher's Interview-About-Instances

1. Ice-breaking session (5 - 10 minutes)

The researcher explains the purpose of the interview which is to explore teachers' conceptions about primary science teaching. This is followed by some general questions with regards to the participant's experience in teaching in general and more specifically in the new science curriculum.

2. Interview-about-instances (40 minutes)

Preamble to the interview:
Researcher: In this review, I would like to listen to your views of teaching primary science. I will present you with a series of instances of science teaching, the content of which is based on the primary science curriculum. For each instance, I will ask you the following questions:

1. Would you teach the topic in the same way as shown on the card?
2. If the answer is 'yes', please give your reasons.
3. If the answer is 'no', please give your reasons and suggest an activity which you would use instead?
3. You may also modify the instance if you wish. What modifications would you make and why do you make the modifications?

I have no expectations about your answers. In other words there are no right and wrong answers. I am really interested in hearing how you personally think about teaching primary science.

The teacher is free to ask any question to clarify what he/she is supposed to do. The teacher will be given the cards which contain the ten instances. He/she can choose the order in which he/she would like to talk about the instances.

The ten instances are:

1. Teacher explains breathing mechanism of various animals.
2. Pupils plan an experiment to compare the sizes of two containers.
3. Pupils discuss the origins of different objects.
4. Pupils watch videotapes on the historical of development of science and technology on transportation.
5. Teacher invites a speaker from the community for a science lesson.
6. Pupils record the different phases of the moon over a period of one month.
7. Pupils act out the role of the sun, earth and moon.
8. Pupils carry out experiments to determine the elasticity of different materials.
9. Teacher brings pupils for a visit to a museum.
10. Pupils design the 'best' bag.

3. Overall view of primary science teaching (5 - 10 minutes)

3.1 What do you see as the important goals of primary science education?
3.2 What do you consider as effective science teaching?
3.3 In your opinion, what are the characteristics of an effective primary science teacher?

The researcher thanks the teacher for sharing his/her views on primary science teaching.

Appendix D3
Teacher's Curriculum Interview

Researcher: This interview aims to investigate (i) support available to the science teachers, (ii) your understanding of the primary science curriculum policy, and (iii) your views of the primary science curriculum.

1. From your experience in teaching, you are bound to find that certain topics are more difficult to understand and to teach. What do you normally do to overcome these difficulties?

   (Possible answers: a. discuss with other science teachers in the same school; b. discuss with other science teachers in another school; c. discuss with science officers in the education department; d. refer to books; e. follow the textbook and give it a try; or others)

2. How helpful are these approaches in overcoming your problems?

3. What are the available facilities for science teaching in your school?

4. What other major problems do you encounter as a science teacher?

5. How do you see the role of the school administration in helping to overcome these problems?

6. How often are science meetings held in your school?

7. What matters are discussed in these meetings?

8. What types of support would you like to have as a science teacher?

9. What are the aspirations of the science curriculum in relation to the following aspects?
   (i) nature of science, (ii) role of learners, (iii) role of teachers, (iv) teaching strategies, and (v) assessment.

10. What are your views about these aspirations?

11. What is your understanding of the constructivist model of teaching as advocated in the science curriculum? What are your personal views about this model?

12. What is the main emphasis in the new science curriculum that is different from that found in 'Man and His Environment'?

Appendix E1

Letter To EPRD Requesting Permission to Carry out the Study

14 Carow Street
Palmerston North
New Zealand

---

31 Disember 1996
Rujukan: KP(BB)01/2/1995(21)

Pengarah,
Bahagian Perancangan dan Penyelidikan Pendidikan,
Kementerian Pendidikan Malaysia,
Paras 2,3 & 5, Blok J,
Pusat Bandar Damansara,
50604, Kuala Lumpur.

Tuan,

Memohon Kebenaran Menjalankan Penyelidikan di Sekolah
Rendah Sabah untuk Memenuhi Keperluan Program PH.D
di Massey University, New Zealand

Saya sedang mengikuti program PH.D. dalam bidang pendidikan science di Fakulti Pendidikan, Massey University, Palmerston North, New Zealand.

Di sini, saya ingin memohon kebenaran tuan untuk menjalankan penyelidikan di tiga buah sekolah rendah di sekitar Kota Kinabalu, Sabah. Sampel penyelidikan juga melibatkan tiga orang ahli Panel Penggubalan Kurikulum Sains Sekolah Rendah. Tajuk penyelidikan ialah ' Mengkaji Implementasi Kurikulum Sains Baru Sekolah Rendah Malaysia' and cadangan penyelidikan pun telah diluluskan oleh penyelia saya dan disokong oleh Ketua Jabatan berkenaan. Penyelidikan ini akan bermula pada bulan Mac, 1997 and tamat pada akhir bulan Mei, 1997.

Disertakan bersama surat permohonan ini ialah:

i. dua salinan borang penyelidikan BPPP I ,
ii. dua salinan cadangan penyelidikan,
iii. dua salinan jadual kerja, dan
iv. dua salinan instrumen kajian bersama sampel.

Jasa baik tuan untuk mempertimbangan permohonan saya didahului dengan ribuan terima kasih.

BERKHIDMAT UNTUK NEGARA.

Saya yang menurut perintah,

Jeannie Ling Ai Yieng

s.k.

1. Pengarah
   Malaysian Student Department
   No.10, Washington Avenue
   Brooklyn, P.O. Box 9422,
   Wellington, New Zealand

2. Setiausaha Bahagian,
   Bahagian Biasiswa,
   Kementerian Pendidikan Malaysia,
   Paras 6, Blok E (Utara)
   Pusat Bandar Damansara,
   50604, Kuala Lumpur

Appendix E2
Permission Letter from EPRD

BAHAGIAN PERANCANGAN DAN
PENYELIDIKAN PENDIDIKAN,
KEMENTERIAN PENDIDIKAN,
PARAS 2, 3 DAN 5, BLOK J,
PUSAT BANDAR DAMANSARA,
50604 KUALA LUMPUR

Telefon: 2556900
Kawat: "PENDIDIKAN"
Faks: 03-2554960

Ruj. Tuan:

Ruj. Kami: KP(BPPP)13/15
Jld.48(735)
Tarikh: 20 Jan 1997

Pn. Jeannie Ling Ai Yieng,
14 Carow Street,
Palmerston North,
New Zealand.

Puan,

Kebenaran Bagi Menjalankan Kajian Ke Sekolah-Sekolah, Jabatan-Jabatan Dan Institusi-Institusi Di Bawah Kementerian Pendidikan Malaysia

Adalah saya diarah untuk memaklumkan bahawa permohonan puan untuk menjalankan kajian mengenai

"Implementation Of Malaysian New Primary Science Curriculum".

diluluskan.

2. Kelulusan ini adalah berdasarkan kepada hanya apa yang terkandung di dalam cadangan penyelidikan yang puan kemukakan ke Bahagian ini. Kebenaran bagi menggunakan sampel kajian perlu diperolehi daripada Ketua Bahagian/Pengarah Pendidikan Negeri yang berkenaan.

3. Puan juga dikehendaki menghantar senaskhah hasil kajian puan ke Bahagian ini sebaik sahaja selesai kelak.

Sekian.

"BERKHIDMAT UNTUK NEGARA"

"CINTAILAH BAHASA KITA"

Saya yang menurut perintah,

(DR. ABD. KARIM B. MD. NOR)
b.p. Pengarah Perancangan dan Penyelidikan Pendidikan,
b.p. Pendaftar Besar Sekolah-Sekolah dan Guru-Guru,
Kementerian Pendidikan.

Appendix E3
Letter To Sabah State Education Department Requesting Permission to Carry out the Study in the Two Schools

17 Teck Guan Villa
Lorong Tupai 3
Jalan Penampang
88300 Penampang

---

12 Mac 1997

Datuk Pengarah Pendidikan
Jabatan Pendidikan Sabah
Tingkat 5, Rumah Persekutuan
Kota Kinabalu, Sabah

Datuk,

Memohon Kebenaran Menjalankan Penyelidikan
di . dan

Saya, dengan segala hormatnya, ingin merujuk Datuk kepada perkara tersebut di atas. Untuk makluman Datuk, saya sedang mengikuti program PHD (Pendidikan Sains) di Massey University, New Zealand di bawah Biasiswa Kementerian Pendidikan Malaysia. Saya akan mengkaji implementasi Kurikulum Baru Sains Sekolah Rendah di dua buah sekolah di sekitar mulai 17 hb Mac hingga 15 Mei 1997. Kebenaran telah diperolehi dari Bahagian Perancangan dan Penyelidikan Pendidikan (EPRD) dan salinan surat kebenaran dilampirkan bersama.

Saya telah berbincang dengan guru besar and guru besar and mereka telah setuju untuk melibatkan sekolah masing-masing dalam kajian ini.

Di sini, saya ingin memohon kebenaran Datuk untuk menjalankan kajian saya di sekolah tersebut. Kerjasama Datuk dalam perkara ini sangat-sangat saya hargai dan didahului dengan ribuan terima kasih.

Sekian.

BERKHIDMAT UNTUK NEGARA

Saya yang menurut perintah,

(Jeannie Ling Ai Yieng)

Guru Besar
Sila beri
kerjasama

Appendix F1
Information Sheet for Head Teachers

Project Title: Implementation of Malaysian Primary Science Curriculum

Information Sheet (Head Teachers)

Dear Mr./Mrs./Miss ,

This letter is intended to provide a brief introduction to my research project and invite your participation.

After having been a science teacher educator for 18 years at Gaya teacher training college, Kota Kinabalu, Malaysia, I am currently undertaking a PhD degree in Education at Massey University, New Zealand under the sponsorship of the Malaysian Ministry of Education.

As part of my doctoral degree, I am engaged in a research project which looks at the implementation of the new primary science curriculum in two exemplary schools. As your school is on the list of recommended schools, I invite you and two of the science teachers to participate in the study. I would like to request you to nominate two experienced science teachers whom I can work closely over a period of ten weeks from 10 March 1997 to 16 May 1997. For these two teachers, a total of four interviews will be held, and their science lessons observed over a teaching unit not exceeding three weeks. They will also fill in a questionnaire relating to some general background information. Written consent will be sought from all participating teachers.

You are requested to fill in a questionnaire relating to general information about the composition of your school. This will take about ten minutes. As I am also interested to find out the approach and support your school is able to provide to the science teachers, I will ask you a few questions relating to these matter in an interview. The interview will last between 45 minutes and an hour and will be audiotaped. The interview time will be set for your convenience.

I would like to assure you that all the information you provide will be treated with full confidentiality. The anonymity of your school, teachers and students will be assured by the use of substitute names in all documents. You will be given summary or transcript of the interview session in which you have participated and you can change any points which you feel that I may not have understood.

The tape will be transcribed in full. In the case of the tape being transcribed by another person other than myself, I will undertake the responsibility to obtain a confidentiality agreement signed by the transcriber. The interview tape and transcript will be safeguarded with access limited to only myself and the thesis supervisory committee. Access of the tape and transcript to any other persons will only be made available with your written permission. I will retain the tape during the course of the study and will destroy it after completion of the research process. I may request to retain the tape and will only do so with your written consent. A summary of the study will be made available to you.

It is hoped that the findings of the study relating to experienced teachers' understandings and views towards the new curriculum, their practices, and the supports the school management makes available to them will provide the curriculum developers with some insight into the needs of the teachers in the planning of in-service courses for them and in providing them with the relevant support.

If you have any questions regarding this research, please do not hesitate to contact me (the researcher) or my thesis supervisors at the following addresses.

1. Researcher: Jeannie Ling Ai Yieng
17 Teck Guan Villa,
Penampang,
Kota Kinabalu, Malaysia
Telephone: 088-215243

2. Supervisor (Chief) Dr. Alison St. George
Department of Educational Psychology,
Massey University College of Education,
Palmerston North, New Zealand.
Telephone: +64 6 350 4533

3. Supervisor Dr. Heather Ryan
Department of Professional Studies
Massey University College of Education,
Palmerston North, New Zealand.
Telephone: +64 6 357 9104 Ext 8820

The success of this study depends very much on your willing co-operation and support. Thank you.

Jeannie Ling

March 1997

Appendix F2
Information Sheet for Teachers

Project Title: Implementation of the Malaysian Primary Science Curriculum

Information Sheet (Teachers)

Dear Mr./ Mrs./ Miss ,

This letter is intended to provide a brief introduction to my research project and to invite your participation.

After having been a science teacher educator for 18 years at Gaya teacher training college, Kota Kinabalu, Malaysia, I am currently undertaking a PhD degree in Education at Massey University, New Zealand under the sponsorship of the Malaysian Ministry of Education.

As part of my doctoral degree, I am engaged in a research project which looks at the implementation of the new primary science curriculum in two exemplary schools. As your school is on the list of recommended schools, I invite you to participate in the study. I am interested to find out experienced science teachers' understanding and views of the curriculum, their classroom practice and the problems they face in implementing the curriculum.

I would like to congratulate you as you have been nominated by your head teacher to participate in this study. This study will involve classroom observations and interviews which will take over a period of ten weeks from 10.3.97 until 16.5.97 At the beginning of the study, you will be requested to fill in a questionnaire to provide some general information relating to your experience in science education. This will take about ten minutes. You will be involved in four sessions of interviews with an average of one interview per week. Each interview session will last between 45 minutes to an hour. Interview times and locations will be set for your convenience. In these sessions, I would like you to share with me your experiences in science education concerning various science teaching strategies and the problems you face. All interview sessions will be audiotaped. I will also be observing your science lessons for one class of your choice over a teaching unit. The number of lessons depends on the unit taught but it will not exceed three weeks. All lessons will be videotaped.

I would like to assure you that all the information you provide will be treated with full confidentiality. The anonymity of your school, head teacher, teachers and students will be assured by the use of substitute names in all documents. You will be given summaries or transcripts of interview sessions in which you have participated and you can change any points which you feel that I may not have understood.

All audiotapes will be transcribed in full. In the case of the tapes being transcribed by another person other than myself, I will undertake the responsibility to obtain a confidentiality agreement signed by the transcriber. All tapes and transcripts will be safeguarded with access limited to only myself and the thesis supervisory committee. Access of tapes and transcripts to any other persons will only be made available with your written permission. I will retain all tapes during the course of the study and will destroy them after completion of the research process. I may request to retain certain tapes with your written consent. A summary of the study will be made available to you.

It is hoped that the findings of the study relating to your understandings and views towards the new curriculum together with your practices will provide the curriculum developers with some insight into the needs of the teachers in the planning of in-service courses for them and in providing them with relevant support.

If you have any questions regarding this research, please do not hesitate to contact me (the researcher) or my thesis supervisors at the following addresses.

1. Researcher: Jeannie Ling Ai Yieng
17 Teck Guan Villa,
Penampang,
Kota Kinabalu, Malaysia
Telephone: 088-215243

2. Supervisor (Chief) Dr. Alison St. George
Department of Educational Psychology,
Massey University College of Education,
Palmerston North, New Zealand.
Telephone: +64 6 350 4533

3. Supervisor Dr. Heather Ryan
Department of Professional Studies
Massey University College of Education,
Palmerston North, New Zealand.
Telephone: +64 6 357 9104 Ext 8820

The success of this study depends very much on your willing co-operation and support. Thank you.

Jeannie Ling

March 1997

Appendix G1
Head Teacher's Consent Letter

Project Title: Implementation of Malaysian Primary Science Curriculum

Consent Form (Head Teachers)

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without any permission. The information will be used only for this research and publications arising from it.

I agree / do not agree to the interview being audio-taped.

I also understand that I have the right to ask for the audiotape to be turned off at any time during the interview.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ______________________________

Name: ______________________________

Date: ______________________________

Appendix G2
Teacher's Consent Letter

Project Title: Implementation of Malaysian Primary Science Curriculum

Consent Form (Teachers)

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without any permission. The information will be used only for this research and publications arising from it.

I agree / do not agree to the interview being audio-taped.

I agree / do not agree to my lessons being video-taped.

I also understand that I have the right to ask for the audio/video tape to be turned off at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ______________________________

Name: ______________________________

Date: ______________________________

Appendix H1
Head Teacher's Questionnaire

Questionnaire to be filled by the head teacher

This purpose of this questionnaire is to find out some background information of the composition of the school and the staff. All information given is treated as confidential and therefore no identity of the persons or schools will be published in the report. Thank you.

A: School

School type: *SR / SRK / SRJK (C)
Grade of school: *A / B / C
School sessions: *Morning / Afternoon / Morning and Afternoon

Number of classes:

Primary One	
Primary Two	
Primary Three	
Primary Four	
Primary Five	
Primary Six	

B. Head teacher:

Sex:
Age:
Academic qualification:
Professional qualification:
Number of years of experience as a teacher:
Subjects taught:
Number of years of experience as a headmaster:
Subjects taught (if any):

C. Pupils:

Girls		Bumiputera	
Boys		Non-Bumiputera	
Total		Total	

* Delete where appropriate

D. Teachers:

Men		Bumiputra	
Women		Non-Bumiputera	
Total		Total	

Trained	
Untrained	
Total	

E. Science Teachers:

Trained	
Untrained	
Total	

Attended science-related courses	
Never attended any science-related courses	
Total	

Appendix H2
Teacher's Questionnaire

This questionnaire is to be filled by the science teachers.

This is part of a study to evaluate the implementation of the Malaysian New Primary Science Curriculum. The study is required to meet the fulfilment of a doctoral programme undertaken by the researcher at Massey University, Palmerston North, New Zealand. All information provided will be treated with full confidentiality and no names of persons or schools will be published in the report. Your co-operation is very much appreciated.

Personal data

1. Sex: ☐

2. Race: ☐

3. Age: (Tick in the appropriate box)
   - less than 25 years ☐
   - 25 - 30 years ☐
   - 31 - 35 years ☐
   - 36 - 40 years ☐
   - 41 - 45 years ☐
   - 46 - 50 years ☐
   - more than 50 years ☐

4. Teaching experience (years) ☐

5. Science teaching experience (in years)
   - 'Man and His Environment' ☐
   - Science ☐

6. Highest academic qualification (Tick in the appropriate box)
   - LCE/SRP/PMR ☐
   - SC/MCE/SPM ☐
   - HSC/STP/STPM ☐

7. Science or 'Man and His Environment' course attended (Tick in the appropriate box)

1992	
1993	
1994	
1995	
1996	

8. Highest qualifications in science (Tick in the appropriate box)

Subject	PMR/SPM/STPM
General Science	
Biology	
Physics	
Chemistry	
Human and Social Biology	
Other (Please specify)	

9. Subjects taught this year

Subject	Class	Number of periods per week

10. Other duties

Form teacher	
Head of subject	
Counselling teacher	
Club advisor	
Games	
Senior assistant	
Others (please specify)	

Appendix I1

Mrs. Chan's Science Teaching-Learning Strategies

Interview Transcript

Time: 4.45p.m. to 5.30 p.m.

Date: 10 April 1997 (Thursday)

Researcher explained to the teacher the purpose of the interview which is to investigate teacher's understanding of the various methods used in primary science teaching. The researcher also told the teacher to look through the list shown and check which are not familiar to her as these will not be included in the discussion. Teacher was not sure about simulation. So simulation was left out. The teacher asked whether role play is the same as acting. It was then agreed to use acting instead of the role play.

MRS. CHAN: In experiments, we ask pupils to do and find out the conclusion. They do this to prove something.

R: What do you do in experiments?

MRS. CHAN: Sometimes, we cannot do it in the class like growing the plants. The teacher will tell them what to do. It is also explained in the book. They did it at home and they will bring to the class to observe. They do not leave them in the classroom. During the science lesson, they will bring. In the morning, the standard two pupils are using the same class. They themselves are worried. They will bring home. Sometimes, if they forgot to bring the books home, the books got torn.

R: After they have done it, did they note it down?

MRS. CHAN: They measure and also observe the leaves.

R: Did they record it in their exercise books?

MRS. CHAN: They drew. They did not actually measure it. They noticed they grow taller. Some of their containers are small. After three days, they already grew out of the container. So they know they have grown - not actually measure it.

R: If the teacher wants them to learn the measuring skills, they will need to measure it. So you have done this experiment?

MRS. CHAN: Yes.

R: Can you give one more example?

MRS. CHAN: We use the type of leaves where the roots grow from the leaves.

R: Do you think that it is an experiment?

MRS. CHAN: I do not know whether it is. If they can do it, I let them do.

R: According to you, you could do more experiments in which field?

MRS. CHAN: It is easier for the material things. For animals, most of the time, we look at the pictures.

R: If somebody helps you to catch the animals, will you use them?

MRS. CHAN: I will show it to the pupils.

R: Now we talk about teacher demonstration. Have you done teacher demonstration?

(S1:T2:I1:P1)

MRS. CHAN: I am not very sure this is called demonstration. To show that there is air in the leaves, we put in warm water, bubbles can be seen. I did not do it in class because I need warm water. I asked the pupils to do at home. Some of them told that there are bubbles coming out of the leaves.

R: What do you as the difference between pupils experiment and teacher demonstration?

MRS. CHAN: Like in Physical Education, the teacher demonstrates an action for pupils to see. I do not see the difference between the two in science

R: It can also be an experiment, the teacher will show to the pupils. Sometimes there is not enough equipment or sometimes the experiment is dangerous. Is there any occasion when you use teacher demonstration?

MRS. CHAN: I use a globe and show them the movement of the earth.

R: When you did experiments with the materials, did you demonstrate or you let them do?

MRS. CHAN: I did first and asked them to try. Some clothes can absorb water and some cannot. I called one or two from each group to come out and do. I also asked them to pull.

R: It has the characteristics of teacher demonstration. Did you divide into groups?

MRS. CHAN: The things are not enough. Some did not collect and some did not bring.

R: If there are enough things,

MRS. CHAN: It is better for two or four persons to do in groups so that they will not waste time.

R: Did they record anything?

MRS. CHAN: They fill in the table form stating which absorb water and those that do not.

R: What about visits?

MRS. CHAN: I have not done any.

R: What about projects?

MRS. CHAN: Very often, we talk about projects. It is like an activity. May be you have to collect, you cannot do it in one period. You need more time to carry it out. You have to plan. You cannot do it within one hour in the class.

R: Did you do any project?

MRS. CHAN: No. I have not done.

R: Why?

MRS. CHAN: Time is a problem. There is a lot of work to prepare. We cannot just concentrate just on teaching science. There are more important subjects like Malay, Chinese, Mathematics and English. These are the major subjects. Last time, Man and His Environment is only minor subject and not so important. Only the four subjects are counted to determine the position in the class.

R: No wonder, the marks for science are not displayed on the staff room display board.

MRS. CHAN: Even for promoting to better classes, only the four subjects mentioned earlier are considered. We still emphasise on these four subjects.

R: What about pupil discussion? The pupils discuss among themselves.

(S1:T2:I1:P2)

MRS. CHAN: I have not tried this. It is the same problem. I feel the pupils do not have the training. Maybe we should give them a suitable topic . Otherwise, they make noise only. I feel troublesome to do it. I did not do it in science. I do it in Chinese composition writing. I divide them into groups. They will write it on a piece of paper. They pass it up. The stories are different. I read out to them.

R: They will not come out to read?

MRS. CHAN: Sometimes they read. Sometimes I read.

R: If you use this method in Chinese, why don't you use it in science?

MRS. CHAN: It can be used for any subject. I want to finish a certain topic during the week. I think this method needs time. Sometimes, I will continue the maths lessons in a science lesson.

R: In this new curriculum, we try to encourage pupils to discuss and think. If the teacher explains, pupils will not have the opportunity to do these. The pupils always think what the teachers say is correct and do not dare to express their own opinions.

MRS. CHAN: Chinese schools are like that.

R: When they go to university, they may find it a problem because they are so used to be spoon-fed by the teachers.

MRS. CHAN: Everything they depend on the lecturers.

R: This is very ideal. The parents, head teacher want good exam results. The curriculum has the aim of producing thinking pupils. Which one has greater pressure on the teacher?

MRS. CHAN: Normally we follow the needs of the parents and the head teacher. If the pupils do not perform well, I feel that it is either the teachers do not finish teaching or the teachers cannot teach properly. To avoid all these, we rush to cover the syllabus.

R: Your emphasis is on the marks scored by the pupils. It does not matter much whether they have the interest to learn.

MRS. CHAN: It is of course important to train the pupils to think scientifically. Marks is the reality. The parents send the children for tuition everywhere after school. The aim is to get good results. They do not care about the teaching methods - even if it is learning by rote. For example, they even memorise the composition. When I was teaching in Kuala Lumpur, the head teacher required us to ask pupils to memorise. Every week they would memorise one composition. There are so many sample compositions, English, Chinese and Malay. They cannot think. They spot the topic. That class, over 40 pupils wrote the same composition in UPSR exam. The committee discussed and these pupils were finally given D.

R: Despite these, they still do it?

MRS. CHAN: They feel it is good for pupils because they hope that they memorise it and will remember some of the expressions. They will be able to use it. I ask them to memorise certain nice expressions.

R: How do you think we can convince the teachers to use different approaches in teaching?

MRS. CHAN: It is not one person's effort. Parents should not emphasise on marks. The school management should also be like that . The education department will determine the target for UPSR. The head teacher announced the target the other day.

R: If the pupils can understand by doing the activities, don't you think they will do well in the exam?

(S1:T2:11:P3)

MRS. CHAN: It should be. But the teachers, we need more time to prepare.

R: In what way can we lessen the work of the teachers like giving you more teaching aids, providing you with the specimens?

MRS. CHAN: If the school has good facilities, has a science lab. Whatever we want are there. If there is, every teacher can do it.

R: Maybe some teachers need some training.

MRS. CHAN: Teaching methods change so often.

R: Teacher explanation. You might have a bit more to say. What do you do to make the explanation effective?
MRS. CHAN: We give points and then explain. If you do not have the points, pupils do not have the focus when they listen to you. Like I want to bring their attention to the animals which give birth, then I explain.

R: What about acting?

MRS. CHAN: Like the movement of the animals like crawling.

R: Many teachers like to do this activity. How do you find this activity?

MRS. CHAN: The pupils are very curious. They enjoy it because it makes them laugh. How the snake move, the earthworm moves, how the insects move, how the frogs jump. They will realise that different animals move differently.

R: If you have grasshoppers, what will you ask the pupils to do about the movement?

MRS. CHAN: See them jump. Look at the breathing holes.

R: What are the parts related to the movement?

MRS. CHAN: Look at the front legs and back legs. Insects have six legs.

R: They can also look at the size of the different legs. Where are the wings attached? For me, these are the important observations to be made to attract pupils' interest. Like which pair of wings are for flying. How to determine which pair are for flying? Do you think this is interesting for the pupils?

MRS. CHAN: It should be interesting for them.

R: I would like to know what the teacher will do if the grasshoppers are given.

MRS. CHAN: I will ask them to look at their legs. Like tying up the wings, I will not do.

R: Sometimes, teachers ask pupils to draw a grasshopper without looking at any grasshopper.
If we give time for them to see or the teacher explains, I feel there is not too much difference in the time. The problem is to find the grasshoppers.

MRS. CHAN: The problem is whether we can catch the grasshoppers.

R: My aim is to listen to different teachers the reasons for not using certain methods. If we can understand why, we could make some suggestions. Suppose the school has a lab assistant who can help the teachers to find the materials. Animals can be preserved or kept in a proper place so that they can be used for teaching respiration, reproduction. I would like to know what type of help can make the work of a teacher easier. What about quizzes?

(S1:T2:11:P4)

MRS. CHAN: No. I do it during the revision. Is it counted as the quiz? I divided them into three groups. I ask a question and whoever can answer. If they get it correct, they will get marks . They do not study. Some of them only remember from what they heard in the class.

R: Do you use this often during you revision?

MRS. CHAN: Yes. I treat this as competition. The pupils are interested in competition. I use it in Chinese and science also.

R: What about printed materials like books? This means like asking pupils to find information from the books.

MRS. CHAN: I asked them to collect pictures of animals.

R: Besides pictures, do you ask them to find information like the history of communication from books in the library?

MRS. CHAN: Very rarely used. Some of them print out information from the computer. Two of them are good at that. Below the picture, there is information about the animals. But it is in English. I have to explain whenever I can.

R: What about the audio visual? I switched on TV, I was watching a program on educational TV on channel 2?

MRS. CHAN: Tonight there is a program at 9.30 p.m. on insects on TV3. This is advertised. The other time, they showed a program on solar eclipse. I did not manage to record it.

R: If the teachers divide the work, somebody is in charge of videotaping some program.

MRS. CHAN: It is not every week.

R: The education TV program is also quite good.

MRS. CHAN: In my previous school in Kuala Lumpur, they bought some video tapes in Chinese on insect reproduction. We used to show to our pupils. They are very good. Here, we do not have the tapes. If the school has a teacher in charge. The teacher will have enough time to do. This depends on the school management. In my previous school, we have. The person in charge has less than ten lessons. Whatever we need, we do not need to look for it. We just tell the person what we want. It will be there for us.

R: Games. Games also have the competition characteristic in it.

MRS. CHAN: Whenever I think of a teaching method, I just do it. I do not think of the name of the method.

R: For example, when we teach the topic on food chains on who eat who. We can write down names of various plants and animals on cards. They can be divided into groups. They need more space. They can be asked to arrange a food chain as long as they can. Invited speakers like parents who are farmers, doctors. Is it possible?

MRS. CHAN: If it is in standard four, may be the invited speakers who are not teachers may not know how to match the pupils' level. Primary six pupils are older -they might be able to understand better. It depends on the speakers whether they can match the pupils' level or not. They need to speak at a low level, then the pupils will be interested. If they speak on difficult ideas, the pupils may not be able to concentrate.

R: If we are using the same method everyday, some pupils may have got used to it and accept it. Some other pupils would be more interested to see some other ways of presentation. What methods do you often use?

(S1:T2:I1:P5)

MRS. CHAN: Teacher explanation, quiz, pupils experiments. The most often used one is teacher explanation.

R: If the school facilities are better, how can pupils understand better?

MRS. CHAN: Should be using the different methods to attract pupils' interest. These methods are all very good and ideal. We have problems if we have to carry them out.

R: If I can convince you that it is easy to obtain the eggs of the mosquitoes by simply putting some water in a bottle and put under a tree for a few days, will you do it? Our government is trying hard to attract students to study in the science stream.

The teacher laughed away.

MRS. CHAN: If you are in science stream, your maths must be good. It is not the interest. It is the government policy. It is easy to do well in arts subjects compared to science subjects. Students find it easy to score high in the exams and are able to get a place in university. Now it is different. For science courses, they have lowered the entrance requirement. It really depends on the government education policy. It is not so much the interest. They cannot afford to go overseas. They want to get a place in the local university.

(S1:T2:I1:P6)

Appendix I2
Mrs. Chan's Curriculum Interview Transcript

Time: 4.45p.m. to 5.45 p.m.

Date: 17 April 1997 (Thursday)

R: Good afternoon. We are going straight to our interview this afternoon. In this interview, I want you to share with me three things: (i) the problems you face when you teach science, the facilities that you have in the school and the facilities that you would like to have but you do not have right now, (ii) what you understand by the new primary science curriculum, and finally (iii) your views towards this new curriculum. First we talk about your problems.

MRS. CHAN: There is no more problem from the curriculum. From the point of the facilities of the school, there is a bit of problem, like teaching materials are not quite enough. What the book suggests and what we would like to do, we do not have. Of course, we can also ask the pupils to collect. If the school has these materials, the teachers can save a lot of time. It is more ideal.

R: You have taught the various fields like the living world, the material world, the physical world, Earth and the Universe, and Science and Technology. Which of these you find more difficult to teach?

MRS. CHAN: Planets and the sun. Also science and technology - if we have enough of reference books and related materials - may be it is not difficult to teach. Our school is especially short of the materials on 'Science and technology'. This may be because 'Science and technology' is a new topic. We are short of charts and also models. Last time, as far as I know, we have a lot of science apparatus. Nowadays, we are short of these things. Maybe it is because of the change from science to Man and His Environment where we do not emphasise so much on science. Only these three years, when science is taken out as a separate subject again.

R: I learnt from your other colleague that this school has the model of the earth, moon and sun in one. Last time, you mentioned about this model and you were not very sure whether the school has this model or not. She has used it in the teaching of Man and His Environment. Could it be that you might not know all the things available in the school?

MRS. CHAN: Maybe. Also sometimes, we really do not go and look for it. So last year, when a few of us taught this topic, I and other science teachers all used the globe only. I know about this model because I have used it in another school. May be because these things are moved from one place to another. Before the new building is built, they were all put in the library. This Saturday, those teachers in charge of the resource centre will be coming back to organise the things. In the old building, these things were also in a mess. I have been here for two years only - I am not so sure. May be the teacher in charge always change - sometimes teachers always change, get transferred. As far as I know, in my previous school, the teacher in charge of the resource centre has gone for courses to learn how to catalogue and so on. The teacher in charge of the resource centre there has very little teaching to do, a few periods only. The teacher in charge of the resource centre in the present school here has a little less to teach, she has to take care of the library, the video, television. Probably she could not manage all. Moreover, there is no special classroom for science.

R: Now, there is. I understand from your headmaster that the science teachers will be coming to organise the science room.

MRS. CHAN: Maybe it is because of the primary six exam.

R: When you face the problem of teaching a certain topic, how do you solve the problem?

MRS. CHAN: If it is from knowledge, I go to library to find some reference books. If we have charts, we use. If not, we just draw on the board.

R: Do you discuss with other science teachers?

(S1:T2:I2:P1)

MRS. CHAN: Sometimes we do. If we have something, we all share. The teachers are all very co-operative. When one teacher finishes using, she passes it to the other teachers.

R: Do you print out exercises for pupils to do?

MRS. CHAN: Last year, for more difficult topics, we wrote in simple sentences and made some simple notes for the pupils. These difficult topics are at the end. This is like additional materials for them. Because what is in the book is sometimes too simple and we feel that they need to know more. For simple topics, we do not do that. This year, we have not.

R: You get help from within the school?

MRS. CHAN: It is only within the school. If I still cannot get, I also discuss with members of the family or read up more books.

R: In what way can the school management help?

MRS. CHAN: Because we are very busy. If we need something and require a lot time to look for it, probably we will not use it. If those in charge catalogue it properly, we could find it immediately when we need to use it. If they are properly arranged, it will really help us. Sometimes we do not know they are available. There is no catalogue even though there is a teacher in charge taking care of the library, TV, video and teaching aids. He mentioned that he needed the help of the head of the subject to arrange the things.

R: One student mentioned about an interesting programme on Astro Television about animals.

MRS. CHAN: But not my class because I have asked them before. It would be good to tape it. After we teach a topic, we can show the tape. This can create interest among pupils.

R: Co-operation among teachers might be helpful to meet the problem of shortage of teaching materials. From my experience in college, we have one week when we do not teach. During the week, the science lecturers discussed various problems in teaching science. We also divided duties among ourselves, with each one looking for certain materials, for example, one of us was made responsible for recording the documentary films on related topics in science. Another one is in charge of looking for relevant materials for development in science and technology. Finally we found that we could produce quite a lot of materials to be shared among us.

MRS. CHAN: This is a good way. During the holidays, teachers come back to do some teaching aids - this is what happens in my previous school. This should be very good. If you have to waste time to look for it, quite likely you are not going to use it. Sometimes, it is also a dirty job like if the place is not taken care of. Last time we went to look for a few charts, we were dirty all over.

R: Your pupils also mentioned about their interest in doing activities. They remembered what they brought and who brought them. They mentioned about acting like animals.

MRS. CHAN: When I taught the movement of the animals, pupils come out to act. They like it very much. The topic is very simple - so there is time to do activity. For some topics, there is so much content that we have to rush to teach it in the five lessons.

R: I thought you would use shorter time if the topic is simple.

MRS. CHAN: Sometimes, there are many holidays in that week, then we have to rush. Recently there is less holiday.

R: Do all the teachers follow the same plan?

MRS. CHAN: Yes. The head of the subject plans for the whole year, that is including the weekly plan. That is photocopied and given to all the subject teachers. All the teachers have to follow. The exam is based on the plan.

(S1:T2:I2:P2)

R: Do you have science meetings? What do you normally discuss?

MRS. CHAN: We had one meeting at the beginning of this year. We discussed the teaching problem, how to set the exam questions, how many percent of each. All teachers will be given the plan for the year. The head of the unit will plan who will set the monthly tests. This is the formal meeting which is held once a year, that is at the beginning of the year. However, when we face problems, we meet informally during the recess time.

R: When you require certain books or equipment, what do you do?

MRS. CHAN: We discuss first and if we find it necessary, we will inform our head of the subject unit who will then inform the afternoon supervisor. The afternoon supervisor will buy or photocopy the materials for us.

R: Are the teachers free to use photocopying facilities?

MRS. CHAN: It has to be through the clerk. We can only photocopy a few sheets. If we want more, we have to type or write on stencils and send to print. We cannot do it ourselves. In my previous school, every teacher can print whatever he/she needs. My previous school is very rich. If you can print on your own, we can do it whenever we want. When you ask them to print and the person in charge is not free, you might not get it the next day and have to wait again.

R: Do you feel you need to attend in-service courses?

MRS. CHAN: It would be good if I can attend. It can help. I do not know who will attend the course in July. I heard last year somebody attended.

R: Some of the teachers have attended the course. For each standard, two teachers would have attended the course.

MRS. CHAN: I do not realise any teacher has gone for any course. There are so many teachers in the morning and afternoon.

R: What does the new science curriculum emphasise?

MRS. CHAN: The new science curriculum encourages pupils to think through the activities. The emphasis is on getting the pupils to do activities and think. In the old curriculum, the teacher gave the answers direct to the pupils. If you look at the activities suggested by the books, the pupils will do the activities and come up with a conclusion.

Researcher showed the teacher the section of the syllabus which show the scientific skills and thinking skills.

MRS. CHAN: We do not have the book. We use the teacher guide book which also contains these. We try to integrate moral values like co-operation among pupils through activities or train their observation. We follow the steps in the book.

R: Does it tell how to integrate into the lessons?

MRS. CHAN: No. We have to think of it ourselves.

R: What about observation?

MRS. CHAN: We use charts and ask them to observe or we bring in the objects for them to observe.

R: How do you encourage communication?

MRS. CHAN: Through discussion and through questions and answers.

R: Do you feel you give all of them opportunities to communicate?

(S1:T2:I2:P3)

MRS. CHAN: Not all because some of them are very quiet. Even when we ask them, they also will not answer. Those who like to answer will always put up their hands. We always use discussion when we introduce a new topic.

R: They also encourage simulation, experiment, discussion and project. What do you feel?

MRS. CHAN: We always use discussion when we introduce a new topic. We also encourage pupils to think.

R: What is your understanding of the inquiry approach, guided discovery?

MRS. CHAN: I do not quite understand. Guided discovery is leading pupils to discover.

R: How did you set the questions?

MRS. CHAN: We refer to our books and workbooks. We do not just copy all of them. We change some.

R: Have you set any test paper this year?

MRS. CHAN: I have not set any this year. I have set the test paper last year. For examples, if there are four topics to be tested. I will divide the questions among the four topics. We have set some difficult, moderately difficult questions as well as easy questions. Some of them are weak. If we set too difficult questions, all of them will fail. Some of the questions have pictures in them.

R: Did you think of some questions which test pupils' scientific and thinking skills?

MRS. CHAN: Some of the other books have questions on experiments with drawing. Using these types of questions, we can also test their skills. It is not necessary to use practical to test these skills.

R: Pupils will be tested their skills in practical activity in primary six. Do you feel it is necessary to start doing it in primary four or primary five?

MRS. CHAN: I think it should be if it is possible. At least they should do the basic.

R: Are these skills in the scientific skills and thinking skills listed in the book?

MRS. CHAN: (Referring to her book). I feel they are mentioned in the book like compare and contrast, classify.

R: For example when you were teaching the life cycle of the insect, you could integrate the sequencing skill. I did not see you ask your pupils to arrange them in the correct order.

MRS. CHAN: Perhaps that was because I did not have the time. In fact, the workbook has this type of question asking them to arrange..

R: Will the teacher face problem to try to integrate all these into a lesson?

MRS. CHAN: There will definitely be because time is not enough. Sometimes we want very much to do it but because of time and our workload, we may not be able to do it.

Researcher showed the teacher a short paragraph from Module 5 (the teaching learning strategies) explaining the constructivist model, hands-on, minds-on.

R: Do you understand what it says?

MRS. CHAN: No.

(S1:T2:I2:P4)

Researcher explained briefly the meaning of constructivist way of learning.

R: For example, some pupils think that whale is a fish. This is their prior knowledge. Sometimes, their prior knowledge can be correct, wrong or partially right. We should find out from them why they call whale a fish. We encourage the pupils to think of the characteristics of whale and compare these with those of the fish group and the mammal group. The pupils can compare and realise that there is some problem with their prior knowledge and that whale has characteristics more like those of the mammals. This theory of learning advocates that knowledge is constructed by the learner himself and not by merely told by somebody. This can be done by discussion, experiments or other activities.

R: What do you feel about this?

MRS. CHAN: This way is OK. You have to change his way of thinking slowly. Teachers face the problem, we have to correct their conceptions.

(S1:T2:I2:P5)

Appendix I3
Mrs Chan's Interview-About-Instances Transcript

Time: 4.45p.m. to 5.45p.m.

Date: 24 April 1997 (Thursday)

R: Can you share with me your experience of learning science as a student?

MRS. CHAN: I am from the science stream. I am actually not interested in science. I am more interested in the arts subjects. I was put in the science class. The main thing was to pass exam. I am from a Chinese school.

R: Can you tell me about how your teachers taught science?

MRS. CHAN: The method is very simple. Majority of my teachers were from China. They asked us to underline the important points in the textbook. Like in Biology, we studied by rote.

R: Did they ask questions?

MRS. CHAN: No. Very rarely because there was a lot in the syllabus. The teacher asked us to underline the important points, explained and gave us notes. In order to pass the exam, we worked hard to remember and memorise

R: During your training as a teacher, did you take science?

MRS. CHAN: I was day trained. We did not study any science, maths. Ours was the last batch. Our juniors studied about Mathematics and Science. We only studied psychology, teaching methods. We had a lot of time and only had half day whereas our juniors studied the whole day.

R: Have you attended any course related to science or Man and His Environment?

MRS. CHAN: Very rarely. That was in 1970s. It was the old science when they changed the syllabus.

R: Did you still have any impression of the course?

MRS. CHAN: No, I do not have much impression. The course was like the usual. The lecturers lectured and gave us notes. I have not attended any courses for a long time.

R: I just have to know a little about your background in science. There are 11 instances listed here. I would like to take one instance at a time. First I would like you to say whether this instance is suitable for primary four pupils and give your reasons. Secondly, you talk about other activities which are suitable for the particular topic. Thirdly, you tell me which activity you will use in your lesson. Would you like to choose one?

MRS. CHAN: It does not matter. I will start with number one about teacher explaining about how animals breathe. It is suitable. Teacher can explain first our breathing. The method is OK. We can also explain and ask them to do at the same time like through their experience, for example they can close their nose.

R: What about the breathing of other animals?

MRS. CHAN: We can use insects like grasshoppers which breathe through breathing holes on the abdomen. They do not have lungs. We can catch the grasshoppers and observe how they breathe. They have breathing holes on the abdomen and tell them they breathe through them. They can also observe how fish breathe, the way they open and close the mouth

R: When you taught this topic last year and this year, how did you teach this topic?

(S1:T2:I3:P1)

MRS. CHAN: For fish, I asked them to bring. Last year, one pupil brought. This year, nobody brought anything.

R: Did you ask them to bring?

MRS. CHAN: Some of them rear fish at home. They did not bring. I used chart.
R: Do you see problems in getting the pupils to bring things to the class?

MRS. CHAN: It depends on the class. Though some of them rear fish, they do not want to bring because they are scared that they will die. We have to bring ourselves. That means they depend on the teachers to bring. In the rural schools, children dare to catch fish. It is more problematic with town school children.

R: Did you ask them to bring insects?

MRS. CHAN: I asked them to bring cockroach. They did not bring. Grasshoppers are a bit difficult to catch.

R: How did you teach this topic?

MRS. CHAN: I used chart and tell them. I asked thosewho reared fish. When I asked them, they will tell a certain part open. I will explain about the gills. They said the fish drink water. I tell them that when fish drink water, they are actually breathing. They also noticed when one part opens, the other part closes.

R: How did you explain to them?

MRS. CHAN: Air is in the water. There is exchange of oxygen and carbon dioxide at the gills.

R: The second one is about the visit to the museum.

MRS. CHAN: I have never brought pupils to anywhere.

R: If you arrange a visit to somewhere, what preparation does a teacher have to make?

MRS. CHAN: You have to relate to the content of the subject. If like going to museum, probably something like history. When you go there, you have to explain those things used in the ancient time, their clothings.

R: Before they go for the visit, will you give them the activities you expect them to do?

MRS. CHAN: You can divide them into groups. One group can do transport. This will make sure that they have time. They can see together but they jot down notes according to the work given to their group.

R: Why you don't seem to want to organise visit for the pupils?

MRS. CHAN: It is really the time problem. Unless you take the weekend, there is really no time for it during the weekdays. In the morning, they have tuition. Sometimes the parents are not sure whether the teachers could take proper care of their children. Last time, there was a snake exhibition. We arranged for them to go. Very few of them went - some of them did not want to go while others said that their parents did not allow them.

R: Next one is about the pupils having to think for themselves one way of comparing the sizes of the containers. The teacher does not explain to them how to find out which one is bigger. Do you think the primary four pupils can do that?
(Teacher was not very clear. Researcher repeated the explanation)

MRS. CHAN: You mean they themselves. It depends on their experience in daily life. For example, to find the volume of a solid. They can relate it to the story of the crow where the stone is dropped in to get the water to rise up.

(S1:T2:I3:P2)

R: For example, I give you two containers. Can you please tell me how you would do it?

MRS. CHAN: I will fill one container with water until full. Then pour into another container and see the level to determine which one is bigger. If it is a box, we can use sand and see how much we can put.

R: I will use another method. I will use a cup and try to find out how many cups are needed to fill the two containers respectively. (Teacher agreed repeatedly). There are many solutions to a problem. (Teacher again agreed) Some ways may be better than others. In the new science curriculum, we try to encourage pupils to think. Therefore we should provide them opportunities to think. Thinking skills are difficult to acquire through following teacher instructions alone. Do you think your pupils can do this?

MRS. CHAN: I think my class pupils may not be. If it is the best class, maybe they can. This is because the way they think depends on their experience in daily life about measuring things. If we ask them things which are not related to daily life, my pupils will not be able to think. My pupils think very direct.

R: Then we can think of something related to daily life like comparing buying a tin of cola and a bottle of cola - which is cheaper. We have to provide them with opportunities to think. Probably, we can start with something simple, like two containers rather than a few containers. Probably they will slowly learn to think. Sometimes a pupil can score full marks in an exam but when pupils are given a problem to solve, they are not sure how to do it. What other ways to teach volume?

MRS. CHAN: We can use cups, bottles. Ask them to measure. It is divided into liquids and solids. Liquids do not have a fixed shape. If we want to measure the volume of the liquid, we can use measuring cylinders to measure. We have some measuring cylinders in the resource centre.

R: What methods would you use to teach volume?

MRS. CHAN: Last year, I used a box. I gave them small and big boxes of different volumes and asked them to compare. If they buy canned food, there are big and small as the size of the tins is written in ml.

R: Did you ask them to do?

MRS. CHAN: No. I did not. They know about canned food. They compared the size of the boxes.

R: Pupils discuss the origins of the objects. For example, the tape recorder here - what is it made of? They may say plastic, iron, rubber. Then they discuss the origins of these materials. Pupils can be divided into groups. Each group can choose five or ten objects and they discuss. After which they can present what they have discussed. This is what is meant here. Is there any other ways of teaching this topic besides using discussion?
(Teacher was trying hard to think).

R: Do you remember what did you do last year?

MRS. CHAN: I cannot remember very well as it was the first year I taught. Normally, I show them the clothings and ask them what it is made of. They will say cloth and we ask them for example where cloth comes from. I used the old fashioned way.

R: You always question a little and explain a little. You do not let them discuss on their own. Why is it?

MRS. CHAN: Yes. I have already told you last week that I have always rushed to teach other lessons. Sometimes, I may not use the two science lesson given. I may use it for another subject. For me, discussion takes a lot of time.

R: Pupils watch video on historical development of science and technology in the field of transportation.

(S1:T2:I3:P3)

MRS. CHAN: If there is video related to the topic, it is good and I will use it.

R: How would you teach this topic?

MRS. CHAN: I will use charts. For transport, in ancient times, they used horse carts, man-pulled carts. We have charts and some of them are found in the book. Normally it is like that. It is divided into transport, communication, who invented them. Mostly we discussed.

R: Will you bring in some books and get them to discuss on their own?

MRS. CHAN: No.

R: Sometimes we feel it might be more interesting to invite a speaker like a doctor to talk about medicine. Have you done this before?

MRS. CHAN: No.

R: Pupils do a project on the different phases of the moon.

MRS. CHAN: I asked three pupils to move around each other acting as the moon, earth and sun. I also use the globe. In my former school, we have a model where the three are joined together, that is, earth, sun and moon are there. I am not sure whether the present school has this model. I talk about how earth moves from east to west. Earth moves around the sun and the moon moves around the earth.

R: Do you feel they understand?

MRS. CHAN: This is the first time they are introduced to this. Through the questions we asked, they could answer. I do not think they have understood one hundred per cent.

R: How do you feel about the topic? Is it difficult to teach?

MRS. CHAN: It is difficult to teach. You can't show it to them. They know about the moon and that during the moon cake festival, the moon is very round.

R: The project here means that one month before the teacher starts to teach the topic. They can be divided into groups. They are to observe the moon every night and draw the moon they see. We leave it to them to think of how they present it - using manila card or make scrap book. In this way, they can use their creativity. When the teacher teaches this topic, we can ask them to talk about it. Do you think they can do it?

MRS. CHAN: It may be possible if the pupils are obedient and do it.

Teacher did not seem convinced.

R: Pupils carry out the experiment to determine the elasticity of different materials.

MRS. CHAN: It is a small part. It also deals with absorbency, shining or not.

R: Did you do the experiments?

MRS. CHAN: We can use string, wire, rubber band and see which one when released goes back to the original form.

R: Did you just discuss or they did it?

MRS. CHAN: OK. They understand why they use rubber band to tie rather than string so that it is tighter.

R: What about the absorbency?

(S1:T2:I3:P4)

MRS. CHAN: We use paper, cloth, tissue paper. That is easy. We are talking about the special characteristics of the materials. Like an umbrella, we cannot use the material which can absorb the water. Why certain cloth material is more comfortable to use? It is a small part introducing the characteristics of each material.

R: The next one.

MRS. CHAN: I do not understand this one.

R: This means after they have learnt the different properties of the different materials, teacher asks them to design a bag - they can choose different materials. They have to think of the function of the bag.. They can do it during their own free time.

MRS. CHAN: They can also do it during the arts lessons.

R: Teacher wants to see whether they know how to apply what they have learnt in the lessons. After they have made the bag, they have to defend for themselves why they consider their bag to be the best. It also gives them confidence to talk in front of the class. Pupils find information from books concerning the good and bad effects of the development of science and technology in our daily life.

MRS. CHAN: For primary four, it should be possible. But we have to find the relevant books. The problem is finding the materials.

R: What do you feel is the role of the pupils?

MRS. CHAN: The pupils should be interested to find things out. They should be trained to observe things. Through activities, we can incorporate co-operation.

R: What activities do they enjoy most?

MRS. CHAN: If we have the space and the time, they enjoy almost any activity. We do not have the science room and we have to look for the things - it is not very convenient. The main problem is the time. The content that we teach is a lot. Because of the exam, revision takes up a lot of time. For teaching, there is no pressure. For exam if the pupils do not do well, we do not feel good.

R: How do you make sure they can do well in the exam?

MRS. CHAN: We repeat the important things over and over again. Do revision. The passing rate is very high. In the previous monthly test, there was only one failure, that is 98% passed in their science. A lot of them do not study when they go home. What they remember is what they heard from the teachers during the lessons.

R: I notice that in your lessons, when you discuss with your pupils, they are obedient and seem to be listening to your explanation. What about for other subjects?

MRS. CHAN: They respect me.

R: You are teaching a number of subjects in the same class. How do you feel about that?

MRS. CHAN: I feel they are very closed to me as I have a lot of time with them. Almost all the form teachers are about the same. We teach the main subjects. We know them very well. Last year, I taught primary four pupils whom I have also taught when they were in primary three. I like it very much. I understand their character very well. I train them and they slowly develop eagerness to learn. Through questions, tests, competitions, we can know whether they understand.

(S1:T2:13:P5)

Appendix I4
Mrs Chan's Stimulated-Recall Interview Transcript

Time: 4.45p.m. to 5.45 p.m.

Date: 3 April 1997 (Thursday)

R: In your first lesson, do you remember what you were trying to teach?

MRS. CHAN: It is about animals that give birth.

R: In your introduction, you were trying to explain why certain animals become extinct. When you asked them the reason, one pupil responded that it was too hot. What did you say?

MRS. CHAN: I heard him but I did not say anything directly to him.

R: How does he know whether his answer is right or wrong?

MRS. CHAN: I feel he can compare his answer with that of the teacher and would find the answer given by the teacher is more correct.

R: If a pupil gives a wrong answer, normally you will not say that it is a wrong answer?

MRS. CHAN: It depends on the situation. In this case, he had a reason and the reason was related to the environmental change which I mentioned.

R: What term do you use for the place where the human baby grows?

MRS. CHAN: Uterus.

R: Sometimes you also mentioned about the stomach?

MRS. CHAN: This is not a good class and moreover it is only an introduction to the topic. They all know about the baby being in the mother's stomach and I did tell them the place in the stomach where the baby grows is the uterus.

R: At the beginning of the year, have the pupils learnt about the different groups of animals like mammals.

MRS. CHAN: No if according to the present syllabus. In the old science syllabus before the introduction of 'Man and His Environment', it was very detailed where they learnt about mammals, reptiles and so on. The present syllabus starts with living and non-living things and they do not learn about the different groups of animals.

R: What are the main ideas that you were trying to teach in the first session?

MRS. CHAN: I only have 30 minutes. First I wanted to teach them the reasons why the animals become less and less in number. Then I introduced the animals that give birth and lay eggs. I followed the points given in the book like the growth of the baby, the number of new born animals, and their conditions like whether they can move when born. 30 minutes was not quite enough. If I have more time, we can compare animals that give birth and those that lay eggs.

R: I understand that you choose to teach the weaker class. Why is it?

MRS. CHAN: I have also taught the best classes before. In my 30 years of teaching, I have taught very good and very weak classes. This class is not really very weak but a little slower than normal class. I personally think that they are weak not that they are not intelligent. There can be so many other reasons. Some of them are weak because of their family background and get very little attention from their parents. As a teacher, I have to try my best to help them and not leave them as such so that they can improve. It is challenging for me to help them to improve. For normal classes, it is easy to teach. You just have to introduce the concepts and they can do it on their own. I am also teaching Chinese and Mathematics in the same class. For Maths and Chinese, I need a lot of time. For Chinese, writing skills are very difficult to teach. Some do not even know how to make sentences even though they are already in primary four. There is a lot of pressure if you teach the good classes because the target is very high. It is not the percentage of passing but the percentage getting A. Parents also put a lot of pressure. For weak classes, my target is not high. So at the end of the year, I can always exceed the target. I feel I am quite successful in that sense. I have taught the weak classes of primary three and primary four and I found it to be very rewarding.

R: If it is a better class, would you teach in the same way?

MRS. CHAN: Most probably I will not explain in such detail. I will repeat many times since I know that my pupils may not listen the first or second time. I know that from my experience and I have to repeat many times. For a good class, I do not need to repeat and we can introduce more materials.

R: Is that why you were just talking about human and not about other animals?

MRS. CHAN: I feel we are more concerned with human, that is ourselves. They are close to us - pupils have seen their mother getting pregnant while not all family keep animals like cats and dogs. Most of them would have seen their mothers in their pregnancy state and given birth to their younger brothers or sisters. They would be interested to know more about it. We can tell them about other animals as general knowledge. Because of the time factor, I emphasize the objectives given in the book.

R: Did you attend any science course recently or have you been briefed by teachers who have attended those courses?

MRS. CHAN: I did not attend any of the courses nor any briefing by those teachers who attended the course. I base it on my own experience and our own way. I have the syllabus, handbook for teacher as my only references and sometimes I use other related books in the library.

R: Your were trying to encourage pupils to think by asking them why fish lay so many eggs?

MRS. CHAN: One pupil answered that there won't be any fish left. He meant that the human eats all the fish. His answer is also one of the reasons. I tried to explain that other fish and other animals in the water can eat up the eggs and the eggs hatch into fry, they are also eaten up by some other fish or even their own parents. If they lay plenty of eggs, at least some will survive. Another pupil mentioned about the fisherman. They are very direct in their thinking and they think only human eat fish. The fishermen catch the fish and sell them and we eat them.

R: Did you try to relate their answers to that of yours?

MRS. CHAN: I just told them my answer and did not relate their answers to that of mine.

R: In your second and third lessons, you explained about the life cycles of butterflies, bees, frogs and chickens. Is that too much?

MRS. CHAN: I think it is a lot. In the book, there are a few types like butterflies and bees. I tried to introduce the various developmental stages in the life cycles of insects. There are different terms for the larva and pupa stages for different insects. Even though they may not remember them, at least they know that the insects undergo different stages.

R: Do you think it is required by the syllabus?

MRS. CHAN: It is in the textbook. The workbook also mentions about this. Therefore I feel I must teach them.

R: You used about twenty minutes to let the pupils to make charts of animals which give birth. What was your purpose?

(S1:T2:14:P2)

MRS. CHAN: This activity is mentioned in the book. By cutting and pasting, this will reinforce their impression of the animals that give birth.

R: You spent one lesson to let the pupils view the video and slides. What do you think about video and slides?

MRS. CHAN: Their impression will be deeper than those obtained from the pictures.

R: What about the educational TV program?

MRS. CHAN: In my previous school in Kuala Lumpur, the school arranged the timetable in such a way that each week, the pupils could watch the program at least once for the subject. Here, up to now, there is none.

R: What was your purpose of showing video and slides?

MRS. CHAN: The most convenient is the chart or the teacher drawing on the chalk board. For television, there is explanation, movement and alive which can arouse pupils' interest in learning. Slides are also good even though there is no movement. I prefer TV compared to slides.

R: Do you think it takes a lot of time?

MRS. CHAN: It all depends. Our syllabus is very packed. Moreover our school has tests which will take one week or to be more exact three days. If your lessons happen to fall within the three days, it means you miss the whole week lessons. In addition to that, normally the week before the tests is meant for revision. I do that but I do not know about the other teachers.

R: Does that mean that for each month, the teacher is left with about two weeks of teaching?

MRS. CHAN: In my former school in Kuala Lumpur, we have three tests and one exam for the whole year. We don't have to rush so much. In this school, we have six tests and two exams for the year. This is the school tradition. We have to rush through the syllabus. All the classes in the same standard will sit for the same test. It is a bit difficult for the weak classes. If you do not cover one topic, parents will complain that the teachers do not finish teaching and the teachers get the blame. Sometimes, before I finished one topic, I went on to the next and came back to revise the two topics together. Then at least I cover all the topics.

R: It must be rather difficult to the less experienced teacher?

MRS. CHAN: Yes, once we had forum with the temporary teachers. They told us that they could not finish the syllabus especially for mathematics and I told them to skip. I also told them that not all pupils are weak and some of them are O.K. and these pupils can learn.

R: Does that mean that there is really no time for activity?

MRS. CHAN: Yes.

R: You did not mention anything eggs and sperms in you lessons. Do you think that it is not suitable for primary four pupils?

MRS. CHAN: The video is meant for secondary one students. This is like sex education. I do not think it is suitable for primary four pupils. Secondary one students are physically more mature and they can understand better. Since it was mentioned in the video, I just mentioned it and did not stress on it.

R: You asked whether whales have long or short life. When one pupil gave long life as the answer, you accepted the answer. What do you mean by long life?

MRS. CHAN: It is written in the book.

(S1:T2:I4:P3)

R: How would you say about your style of teaching?

MRS. CHAN: I feel that it may not be very good.

R: I do not mean whether it is good or bad. I mean what is the role of the teacher and the pupils in your lessons?

MRS. CHAN: The role of teachers is to impart knowledge and skills. We hope pupils can absorb the knowledge. Sometimes, the way we transmit knowledge may not be very good and may be some pupils may not pay attention. So we cannot expect to absorb everything that we tell them. So I always repeat the same thing many times. Some pupils cannot concentrate for too long.

R: The new science curriculum emphasises knowledge, scientific skills, thinking skills and moral values. What do you consider as more important?

MRS. CHAN: Content is fixed by the syllabus and is very important. It is also important we try to guide them to understand properly through discussion, ask questions or through activities.

R: Do you think you must ask them more to let then think?

MRS. CHAN: Asking is good. Time is the main constrain. If you ask too much, you cannot finish in this lesson. I have to rush through the next lesson. Time is a big problem because we try to cover too much.

R: Have you thought of bringing in living things for your lessons?

MRS. CHAN: I have thought about cockroach eggs but I forgot about it. I have planned to explain about cockroach because the young ones look like the mother. The cockroach is different in that it only undergoes 3 stages instead of 4 stages. I find it difficult to find.

R: Do you think the pupils will bring if they are given enough time?

MRS. CHAN: The pupils mentioned that they have seen cockroaches in the cupboards. I did not think of asking them to bring. The textbook does not mention specifically about cockroaches. It depends on the pupils. In good classes, if teacher asks them to bring, they will bring. In my class, I asked them to collect pictures of animals. It took them a long time and still they did not collect much.. I think it is more important to use the pictures and divide them into those which give birth and those which lay eggs. In my class, if I ask them to bring, sometimes they bring. Sometimes they do not bring. They will bring only if they have them at home.

R: I feel it might be a bit difficult for the teacher to bring everything, but if pupils can cooperate, for example like bringing tadpoles, it would be good.

MRS. CHAN: Yes. If you ask them to bring tadpoles, they have to get them from the water. There are a lot of mosquito larvae in the drain. If some accidents happen when they try to get these specimens, teachers will get the blame. It has happened in this school before and we want to protect ourselves. We find it difficult to explain to the parents if some accidents occur.

R: In your last lesson, you referred to the textbook and went through the content. You also went through the exercises with them.

MRS. CHAN: In my class, I have to read through so that they can understand. If I don't go through with them, some of them can't read on their own. If I read, they can listen and understand. There are quite a number of these pupils in my class. If in the two better classes, you can just leave them to do on their own.

(The following portion of the transcript was based on an extra interview to clarify some of issues which were considered important by the researcher but were left out in the other interviews.)

R: I would like to know how you grade your pupils' work.

(S1:T2:14:P4)

MRS. CHAN: The diagrams should be clear, the writing should be neat, the content should be correct. Then only I give them an A. Even if the content is correct, but if it is not neat, I will not give an A.

R: Do you feel the exercises in their workbook are enough?

MRS. CHAN: Not really enough. They also do the exercises in their textbook.

R: Do you prepare extra work for them?

MRS. CHAN: Last year, when we taught more difficult topics like planets and the content in the book is quite messy, we typed some note and distributed to the pupils. If the topic is clear, simple and detailed in their textbook, then we do not give them extra notes.

R: Do you feel you need more reference books?

MRS. CHAN: It depends. If I have time and want to teach in more detail like that day you wanted to see my lesson, then we have to look for more material. Normally, we use what is in the textbook and teacher guide book.

R: Do you use different methods to teach good and weak pupils?

MRS. CHAN: For science, there is not much difference. Science generally deals more with knowledge. Like language and mathematics, we divide them into groups.

R: Do you think all the pupils can learn science?

MRS. CHAN: All of them should be able to learn. If they understand the language, they should be able to accept.

R: Have your teaching methods changed since you started teaching?

MRS. CHAN: There should be. Twenty years ago, the methods were simple and there were not so many activities. Last time we also used charts. However, we did not emphasise much on doing experiments.

R: What about your view of the pupils?

MRS. CHAN: Pupils now have wider knowledge from computer, encyclopaedia. Even the teachers may not have the type of knowledge. Last time pupils only got knowledge from reference books. Parents are also very willing to spend on the education of their children. Some of the wider pupils in the better classes have wider knowledge than the teachers.

R: Which subject do you like to teach?

MRS. CHAN: I like to teach Maths. Even though my pupils are weak, but if I repeat a few times, they do progress and I can see that they can accept it. I find language more difficult to teach. I do not really like to teach science but it is OK. I have to prepare more. If the school inspectors come to see my science lessons, I am expected to use science methods to teach. Sometimes we have to rush because the unit is lengthy.

R: What about your pupils?

MRS. CHAN: They prefer science. Pupils are very curious. Some of what they know may be different from the scientific explanation and they are interested to find out. For Maths, if they can improve, they are also interested.

R: As the head of a subject, what do the other teachers expect you to do?

MRS. CHAN: There is not much. You do the planning and conduct a meeting, record the minutes. It is like a formulae. Occasionally, the younger teachers approach us for help and we will discuss with them.

(S1:T2:I4:P5)

R: What activities your pupils enjoy in the science lesson?

MRS. CHAN: They like all activities.

R: What you have written in the record book, does it help you to plan your lesson?

MRS. CHAN: Not really. It is not like those we wrote during the teaching practice which is rather detailed.

R: So normally how do you prepare your lessons?

MRS. CHAN: I have taught the same topics in the old science curriculum and Man and His Environment. I am already very familiar with the content related to animal reproduction. As for teaching methods, I refer to the teacher guide.

R: Besides using the activities suggested in the teacher guide book, do you think of some other activities?

MRS. CHAN: No.

R: Do you feel the need to attend courses?

MRS. CHAN: During the course, they [the lecturers] talked a lot. Sometimes when we come back, we cannot do it [what was taught in the course] because the facilities are not available. It should be relevant to the facilities of the schools. It would be good if the course is more practical oriented. It is easy to talk. Talking is one matter while doing it is another matter.

(S1:T2:I4:P6)

Appendix I5
Mrs. Chan's Lesson Transcript (I)

Date: 24 March 1997 (Monday)

Time: 4.15p.m. -4.45 p.m.

MRS. CHAN If living things die without giving birth to young ones, they will disappear and become extinct. The process of producing young ones is called reproduction. (Teacher wrote the term reproduction on the board). All living things have to reproduce. If they don't reproduce they will disappear from this world. The purpose of reproduction is to maintain the existence of the species. Our grandparents give birth to our parents and our parents to us. When you grow older, you will get married and have your own children and this will continue. Many animals have become distinct. Why do some animals become extinct?

P(i) [1]: Because they don't have children.

MRS. CHAN Because they don't have children.

P(i): Because it is very hot.

MRS. CHAN Because it is very hot. Some animals have become extinct and some are decreasing in their number. This is because mankind wants development and they cut down forests which are the home of these animals. The environment becomes unsuitable for the survival of these animals. These animals have no home and cannot find food. Human beings also eat turtle eggs which are supposed to hatch into baby turtles. But we are greedy and eat the eggs. They hunt some animals for their meat, use their skin for bags and shoes, and that is why certain animals become less and less in number. Why are some animals becoming less and less? This is because we hunt them. Their homes are destroyed and they don't have enough food and therefore starve to death. For animals that live in the sea, the water becomes polluted and thus becomes unsuitable for them to live in. Now our government does not permit us to catch turtles. The Malaysian government has reserved national parks to conserve animals and plants. It is illegal to remove animals and plants from these parks. In this way animals like tigers and elephants are protected.

(6 minutes)

MRS. CHAN Where do you come from? Does your mother lay an egg and you are inside the egg?

P(c)[2]: (laughing away). No.

MRS. CHAN When your mother is pregnant, she goes to the hospital to give birth. What does she bring back, an egg or a baby?

P(c): Baby.

R: (Pointing to the pictures on the chart). Some animals give birth to the young ones which resemble the parents. For example, the kittens resemble their parents, the newly born calfs also look like the parents. Chickens are different. They also reproduce. In this lesson, we are going to learn about the animals which give birth and not those which lay eggs. The baby of these animals grows in the mother's stomach before it is born. When born, it resembles its parents. These are the animals which reproduce by giving birth. (Teacher wrote the term 'Animals which give birth' on the board.) We don't lay eggs. Cows do not lay eggs and dogs do not lay eggs. Do rats lay eggs?

P(c): No.

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[1] Individual pupil gave the answer
[2] Pupils answered in chorus

(S1:T2:O1:P1)

MRS. CHAN What other animals do not lay eggs but the baby grows in the mother's stomach?

P(i): Elephants.

P(i): Chickens.

MRS. CHAN Do chickens lay eggs? (Teacher asked the pupil who gave chicken as the answer)

P(i): Yes.

MRS. CHAN If it lays eggs, it does not give birth. Do you know? So do hens give birth?

P(c): No.
Other individual pupils gave examples of lion, dog, monkey, leopard, giraffe (Teacher explained that giraffe has long neck), bear and tiger.

(10 minutes)

MRS. CHAN These animals stay in the mother's stomach. They are not born immediately. When we are in our mother stomach, it is like this (pointing to a picture on the chart). How long does the baby stays in the mother's stomach before being born?

P(i): Nine months.

MRS. CHAN Anybody else?

(No response).

MRS. CHAN It is about nine months. As the baby grow bigger and bigger, the mother feels discomfort when she walks or sleep. This is for a long period, not just nine days but nine months, that is three months less than a year. So it is important for you to be obedient to your mother. The baby grows slowly in the mother body until it is mature enough and after nine months it is born. How do we eat when we are in the mother's stomach? Does the mother feed us? (P(c): No) How do we obtain air, water and nutrients. We do not use our mouth to eat.

Teacher pointed to the position of the umbilical cord.

MRS. CHAN There is a hole in every one's stomach where the umbilical cord has been cut away after the mother has given birth. The cord is very long and connected to the mother's uterus. Whatever food the mother eats will go into the blood as nutrients. The blood flows into the mother's uterus and from there the baby obtains air, water and nutrients from the mother by means of blood through the umbilical cord. So that is how the baby obtains air, water and nutrients. It is the same for the calf in a cow. The stomach of a pregnant cat is also big. These are the animals which reproduce by giving birth. Some give birth to one while others give birth to a few. Now let us talk about ourselves. Normally human gives birth to .....

P(c): One.

MRS. CHAN Sometimes we give birth to ....

P(c): Two.

Teacher pointed out the two pairs of twins in the class.

MRS. CHAN Twins are born at the same time. Even though it is possible for human to give birth to three and four babies or even up to seven as reported in the news, it is rather rare. Pigs give birth to a few piglets. How many puppies does a dog give birth to? (Pupils gave answer as six, seven). It is very rare for human to give birth to a few. Normally it is one. There are only two pairs of twins in the class. 38 of you were born singly.

Teacher asked whether they reared dogs and cats at home and have seen them giving birth. Many raised their hands. One pupil mentioned that he has a boy cat.

(S1:T2:O1:P2)

MRS. CHAN Can the boy animals give birth?

P(c): No.

MRS. CHAN Only the girl or female animals can give birth. When the baby is born, the umbilical cord is cut away. The baby has to breathe on its own using its nose and lungs. The mother feeds the baby with milk. These animals are also called mammals. (Teacher wrote the term mammal on the board.) They are called mammals because these animals look after their newly born.

Teacher explained that their mothers looked after them when they were born and that their mothers have to carry them as they cannot move around when they were born. Only when they were a few months old, they learn to crawl. She continued to explain that some animals like kittens and puppies are different as they can move around when they were born. She concluded by saying that animals which give birth are also mammals and that mammals means the mother animal feeds the young ones with milk.

Teacher informed that they would be learning another way of animal reproduction in the next lesson.

(25 minutes)

(S1:T2:O1:P3)

Appendix I6
Mrs. Chan's Lesson Transcript (II)

Date: 26 March 1997 (Wednesday)

Time: 3.45 p.m. -4.45 p.m.

MRS. CHAN: We have learnt about animals which give birth as those animals that grow in the mother's stomach and the newly born resembles the parents. What are some examples of these animals that live on land.

Individual pupil gave examples of dog, cat. and lion. Some other pupils had their hands up. Teacher went on with the lesson.

MRS. CHAN: There are some animals living in water which give birth. What are they?

P(i): Fish.

MRS. CHAN: Fish? It is a big fish. It is a mammal and it gives birth. It milks the new born babies. What is it?
(No response)

Teacher held up a picture of a whale.

P(c): Whale.

Teacher wrote the name on the board.

Teacher showed photographs of other animals which give birth and are living in water found in a book. Teacher read out the names as sea lions, sea dogs, sea leopards and others. Most of these animals take care of their newly born and milk them. Sea lion, sea dog, sea leopards give birth.

(4 minutes)

Teacher wrote the term 'egg-laying animals' on the board.

MRS. CHAN: Today we are going to talk about egg laying animals. There are animals which lay eggs. The mother animal lays the eggs. The baby animal grows slowly inside the egg. When it is big enough, it will crack open the shell to come out. Animals which reproduce in this manner are called egg-laying animals. What is the difference between eggs which have an outer shell and which do not have an outer shell? (In Chinese, there are different terms for the two types of eggs). Does a chicken egg have an outer shell?

P(c): It has an outer shell.

MRS. CHAN: What about duck eggs?

P(c): It has an outer shell.

MRS. CHAN: Chicken, bird, crawling ones like turtle, crocodile, snake and lizards are egg-laying animals that live on land. Fish and frog are egg-laying animals that live in water. What are some other egg-laying animals that live in water?

P(i): Whale.

MRS. CHAN: Not whale. Whale gives birth and does not lay eggs. When your mother wants to fry the chicken egg, she has to crack the shell. Eggs of chicken, duck, goose, snake have shell while eggs of fish and frog do not have shell. Frog eggs are jelly-like. Why do fish have to lay plenty of eggs? The hen lays only a few eggs.

(S1:T2:O2:P1)

P(i): There is no more fish in the water.

MRS. CHAN: Why do the fish become extinct?

P(i): The fisherman.

MRS. CHAN: The fish has to lay plenty of eggs. Do you want to know why? The fish lays plenty of eggs because in the river or sea, they can be easily eaten up by other animals or even by their own parents. The chance of the eggs becoming fry is very low. Even when the eggs hatch into fry, the fry can be eaten by the big fish. You have heard of the expression 'Big fish eat small fish'. Not only are the eggs eaten, the fry are also eaten. That is why the fish has to lay plenty of eggs. A frog lays about a thousand over eggs but a fish lays countless eggs.

The hen looks after the chicks whereas fish and frogs do not take care of their young ones. Fish and frogs are cold-blooded animals because their bodies feel cold. We are warm-blooded because our body feels warm, Chickens and birds are warm-blooded animals as their bodies feel warm. Snakes and turtles are also cold blooded. Eggs of fish and frog need heat to hatch into fry and tadpole. Where do they get the heat from to hatch the egg?

P(i): The sun.

MRS. CHAN: Right. Snake and turtle bury their eggs under the sand. The turtle would make a hole in the sand to lay the eggs and then cover up the hole with sand and then return to the sea. Do they sit on the eggs like the hen?

P(c): No.

MRS. CHAN: Fish, frog, turtle and snake are animals which do not care for their young ones. The egg of a frog hatches into a tadpole. The legs then grow. Which pair of legs of a tadpole grow first?

P(i): Hind legs.

MRS. CHAN: What about the tail?

P(c): Shortens.

MRS. CHAN: The tail shortens and the fore legs grow. It nearly looks like the parents. It breathes using its gills just like the fish. Tadpoles live in water and when they become adult frogs, they live on land. They use lungs to breathe. Frogs are amphibians. Amphibians refer to those animals whose young ones live in the water and live on land when they mature.

Teacher wrote the term 'amphibian' on the board and repeated the meaning of the word.

(16 minutes)

MRS. CHAN: Now we are going to learn about animals which care for the young like the chicken and the bird. One example is the chicken. After six to seven months, the hen will lay the first batch of eggs. Will the cock lay eggs? (Pupils answered 'no'). The cock is like the man and the hen like the woman. The hen will sit on the eggs. Why?

P(c): To give heat.

MRS. CHAN: Not all eggs will hatch into chicks.

Teacher drew the diagram of the cross-section of a chicken egg on the board.

MRS. CHAN: Here is the egg yolk and the egg white (pointing to the egg yolk and egg white on the diagram). If there is a dot on the egg yolk, the egg can hatch into a chick. The dot has like and is called embryo. Eggs which do not have the embryo will not hatch into chicks. The embryo needs air, water and nutrients. (Teacher wrote the three terms on the board). Where does it get air, water and nutrients? It gets air from the air sac and the egg yolk provides the nutrients and egg white provides water.

(20 minutes)

(S1:T2:O2:P2)

Teacher held the chart containing photographs showing various developmental stages of a chick and explained each photograph briefly.

MRS. CHAN: How long does it take for the egg to hatch into a chick? It takes three weeks or 21 days for the egg to hatch. On the 21st day, the shell will crack. The newly hatched chick looks wet. It becomes dry in no time and it becomes a cute little chick. The development of other birds are very similar.

(23 minutes)

MRS. CHAN: We have just learnt that chickens, birds and amphibians lay eggs. There are other animals which lay eggs. I like you to guess. It is beautiful and flies among the flowers.

P(i): Butterfly.

P(i): Dragonfly.

P(i): Bee.

MRS. CHAN: We hate it.

P(i): Fly.

MRS. CHAN: We don't like it. It is harmful to us. It can carry diseases.

P(i): Mosquito.

MRS. CHAN: All these belong to the group of animals called insects. Do they give birth or lay eggs?

P(i): Lay eggs.

MRS. CHAN: We will talk about the butterfly first. The eggs of butterfly do not have an outer shell. It is not like the chicken egg which has an outer shell. Where does the butterfly lay the eggs?

P: Leaves.

MRS. CHAN: What happens to the egg? Does the egg change into a butterfly?

P(c): No.

MRS. CHAN: What does the egg change to?

P(i): Caterpillar.

Teacher put up the chart on the life cycle of the butterfly.

MRS. CHAN: The egg hatches into caterpillar. Caterpillars can be of various colours like black, green or yellow. They look frightening. Are caterpillars harmful or useful?

P(i): Harmful.

MRS. CHAN: Why are they harmful?

P(i): It causes itchiness.

MRS. CHAN: If we don't touch it, it won't cause itchiness.

P(i). They eat leaves.

(S1:T2:O2:P3)

MRS. CHAN: Right. It eats a lot of leaves until it changes to a pupa. Then it stops eating. It hangs on the tree branch and a lot of changes occur. What does the pupa change to?

P(c): Butterfly.

MRS. CHAN: The butterfly when mature will lay eggs. A butterfly egg will change into a larvae, then into a pupa, then to a butterfly. This will go on and on. This will ensure that they will not become extinct.

(29 minutes)

Teacher held the chart on the life cycle of frog for the pupils to see.

MRS. CHAN: The life cycle of frog is different. It does not change four times. The egg changes to tadpole is the young one of the frog. The tadpole slowly changes to frog. Does it have four stages like the butterfly?

P(i): No.

MRS. CHAN: The egg changes to a tadpole which then becomes a frog. The hind legs grow first followed by the fore legs. The tail shortens and it begins to breathe by its lungs. This is the life cycle of the frog.

(30 minutes)

Teacher put up the chart on the life cycle of the bee.

MRS. CHAN: Now look at the bee. It also has four developmental stages. The bee lays eggs which change into larvae and then into pupa and then to the bees. This is just like the butterfly. Bee also changes four times. Insects like mosquitoes and flies also change four times.

(31 minutes)

Teacher wrote the first stage and last stage of the life cycle of the mosquito on the board. Two spaces were left in between for the second and third stages. Teacher explained that the mother mosquitoes lay the eggs in water and that we don't want to breed mosquitoes and so it is important not to keep still water in containers in the house as the mosquitoes will multiply easily in such places. She explained that the eggs change to larva and the larva change into pupa which change into mosquitoes. She wrote the terms larva and pupa in the appropriate space.

(32 minutes)

Teacher did the same thing for flies.

(33 minutes)

MRS. CHAN: I hope you have collected some pictures of animals. I want you to take out the pictures, and divide them into those which give birth and those which lay eggs. If you do not know, you must ask. I don't want you to paste the egg laying animals on to the animals that give birth and the animals that give birth on to the egg laying animals.

Pupils gathered in group of four. Teacher provided each group of pupils with a manila card and asked them to do a chart on animals that give birth. When some pupils approached the teacher for further clarification, the teacher drew the outline of the chart on the board and wrote the topic 'Animals that give birth'. The pupils were reminded to ask if they are not sure of a particular animal.

Pupils did their work diligently. Some pupils referred to the picture dictionary to get the names of the animals.

(50 minutes)

(S1:T2:O2:P4)

Appendix I7

Mrs. Chan's Lesson Transcript (III)

Date: 27 March 1997 (Thursday)

Time: 2.25 p.m. - 2.55 p.m.; 3.15 p.m. - 3.45 p.m.

Topic: Animal reproduction

The 2.25 p.m. - 2.55 p.m. took place in the audio visual room.

Part I - Video watching ***(18 minutes)***

Teacher asked the pupils to sit on the carpet in the front of the television set.

Teacher showed the video tape on the reproduction of animals meant for secondary one pupils. The tape is non-color and is in Bahasa Malaysia. The sound was switched off and teacher explained frame by frame. The video shows reproduction in dog, fish, frog, grasshopper, chicken, rabbit (reproduction organs in the female) and how the foetus of the human gets nutrition from the mother.

Terms like eggs, sperms, internal fertilisation, external fertilisation were also used by the teacher during the explanation.

Teacher summarised by focusing on the two groups of animals, that is the ones that give birth and those that lay eggs.

Part II - Watching slides ***(12 minutes)***

Teacher showed slides of various type of whales, sea lions, walrus and other mammals living in the sea. Teacher provided relevant information for the different slides - sea lions look like lion, use lungs to breathe and give birth to the young; blue whale is the largest animal on earth; killer whale is dangerous and eats meat; those animals that live in the cold climate often have thick layer of fat under their skin to keep themselves warm.

In once instance when the teacher asked the pupils why certain animals living in the cold region are not scared of the cold, one pupil responded that they are cold-blooded. The teacher told them that they are not cold-blooded but are warm-blooded. Another pupil answered that it has thick skin. Teacher explained that a thick layer of fat below the skin helps to keep them warm.

In another instance when the teacher asked them to think one type of whale is given the name killer whale, there was no response from the pupils and the teacher explained to them that it is the most fierce type of whale. Teacher also explained that whales do not use much energy for movement in water and therefore have big body. She related this to the human body - if we eat a lot and do not exercise, we can easily grow fat.

Teacher also asked whether whale has long life or short life, pupils gave the answer as long life and that was accepted by the teacher as the correct answer.

(One pupil from another class came to remind the teacher that it is now the recess time and the teacher is supposed to attend a meeting. She rushed for the meeting.)

Time: 3.15 p.m. -3.45 p.m. Date: 27 March 1997 (Thursday)

Teacher referred the pupils to page 32 of their textbook.

MRS. CHAN: The animals shown in the picture give birth to young ones. All animals die when they grow old. Young animals grow big, reproduce and eventually die. Animals reproduce and die and this goes on. It is the same for human beings. Our grandparents grow old and die, so do our parents and you too will get married when you grow bigger, have children and eventually die. Before you were born, you grew in your mother's body. You will grow from a baby into an adult soon. Humans therefore reproduce by giving birth. Another picture shows the cow which also reproduces by giving birth. Cats also reproduce by giving birth.

(4 minutes)

MRS. CHAN: Some animals give birth to a few young ones while some give birth to just one. Give me examples of animals which give birth to one newly born.

P(i): Human beings.

MRS. CHAN: Dogs, cows and cats can give birth to a few. Some newly born animals can move about on their own. What are some animals which can move about on their own when they are just born?

P(i): Cats.

MRS. CHAN: What are some animals which cannot move about on their own when they are just born?

P(i): Human beings.

MRS. CHAN: Newly born babies cannot move on their own. The mother has to carry the baby. The baby learns to crawl first and only learns to walk when he/she is about one year old. Our mother has to look after us for a long time. For other animals the young animals can look after themselves when they are only a few months old. For us, who still looks after you?

P(c): Mother.

(5 minutes)

MRS. CHAN: Look at the birds on page 34. The mother bird lays eggs which have an outer shell. These eggs hatch into young birds which need to be looked after for sometime. The mother turtle also lays eggs. The turtles are cold-blooded animals and the mother turtle does not sit on the eggs and does not look after the newly hatched baby turtle. Bees are not like birds and turtles. Eggs of birds and turtles hatch into young birds and turtles which resemble their parents respectively. Bees undergo changes in their life cycle. What other animals also undergo changes in their life cycles?

Pupils gave examples of fly, mosquito, and butterfly.

MRS. CHAN: These insects undergo changes. Do their young ones resemble the parents?

No response.

MRS. CHAN: Does the caterpillar look like the butterfly?

P(c); No.

MRS. CHAN: What about us? Does the newly born baby look like its parents?

No response.

MRS. CHAN: Does the baby change into a caterpillar?

P(c): No.

MRS. CHAN: Many animals look after their young ones and some animals do not look after their young ones. Which animals do not look after their young ones?

Pupils gave examples of fish, dragon fly, turtle, frog, fish, butterfly and grasshopper and fly.

(S1:T2:O3:P2)

MRS. CHAN: Some young animals do not resemble their parents. Newly born puppies, kittens, elephants, mice, look like the parents except that they are small. The young of the animals that you mentioned just now like bees, butterflies and others do not resemble their parents. They change four times before they resemble their parents. Another one is the frog where the tadpole does not look like its parents.

(10 minutes)

Teacher asked pupils to take out their work books. Teacher went through the answers of a few questions with them. Pupils were asked to write down the answers. Teacher explained the rest of the questions and asked them to write down the answers on their own. Teacher reminded them to pass up their workbook on the same day. Teacher also asked them to copy the diagrams of the life cycles of two animals in their exercise books. (Exercises attached)

(25 minutes)

(S1:T2:O3:P3)

Pupil workbook **Exercise 20**

A. Underline the correct answer for the following questions:

1. Some animals grow inside the mother body and then born. This way of reproduction is called (egg-laying, giving birth).

2. Some female animals lay eggs which hatch into young ones. This way of reproduction is called (egg-laying, giving birth).

3. Turtles lay eggs (on land, in water).

4. Some young ones do not resemble their parents but when they grow up, they look like their parents, for example (bird, butterfly).

5. (Hen, frog) takes care of their young ones.

B. Classify the following animals according to how they reproduce.

(fish, cow, rat, cockroach, bee, man, lizard, horse)

1. Animals which give birth: a. ________________ b. ________________

c. ________________ d. ________________

2. Animals which lay eggs: a. ________________ b. ________________

c. ________________ d. ________________

Exercise 21

A. Tick ( ) for the right answer and cross ( ) for the wrong answer.

1. All the animals which give birth can give birth to one young one at a time. ( )

2. At the moment there are many endangered animals which are not able to reproduce under unfavourable conditions are under threat of extinction. ( )

3. The eggs of insects do not have outer shell. ( )

B. Circle the correct answer.

1. Which of the following animals have newly borns which cannot move on its own?

A. cow B. dog C. man D. cat

2. Which of the following shows the developmental stages of the animal?

A. Egg pupa cockroach B. Egg tadpole frog

C. Egg larva fly D. Egg caterpillar mosquito

Appendix I8
Pn. Doris's Interview Transcript

Date: 6 May 1997 (Tuesday)

Time: 9.00 - 9.30 a.m.

At the beginning of the interview, the researcher thanked the head master and the teachers concerned for their co-operation given to her.

R: I understand that your school has been doing extremely well in the UPSR exam. Would you like to share with me the secret?

PN. DORIS: That is right. There is no real secret. The teachers have worked very hard and they have been very committed. I have been blessed with a group of teachers who are determined to do their best to help the children as much as they can. The teachers have given extra classes for the children. We have worked as a team. There will be five primary six classes who will be sitting for the primary six assessment test at the end of the year. Normally the teachers will have regular meetings. For example, there are three science teachers teaching the five classes of primary six. They do not work independently, but rather they work as a team. They discuss what topics to teach and the best approach. It is just hard work on the part of the teachers and the co-operation from the parents and of course the students themselves work very hard.

R: This is the third year the new science curriculum has been implemented. What are the successes and problems the school and the science teachers face?

PN. DORIS: I do not see any problem that we have encountered so far. The only thing is because science has not been taught in the primary school as a science subject. It has been integrated in Man and His Environment. This is the third year since science has been taught as a subject on its own. We will be presenting the first group of primary six pupils for the public examination. We have not faced any problem because the children seem to have found the subject interesting. But we do not know. I suppose by the end of the year, we will see whether we are working in the right direction.

R: Do any of the science teachers talk to you abut certain problems in their teaching?

PN. DORIS: Yes, they do. The primary school teachers have been trained to be able to teach all subjects. They have not been give specialised training. Only the last three years, they have been sent for weekend courses or a week courses. Another problem which I face is except for one of the teachers, the other two teachers were not science students. When they were in school, they did general science. But I am glad they have tried their best and I think they have improved a lot by attending courses and so forth. There is a difference when you have real science background. We have to do the best with what we have. That is the problem.

R: To what extent has the administration of the school been supportive to the needs of the science teachers?

PN. DORIS: We have set up the science laboratory. Every now and then, we have the curriculum meetings whereby the head science teacher will attend the meetings. She in turn calls for a meeting with the science teachers at least once a month to discuss the problems and she will bring it forward to us. We do our best. They have done a working paper for the year as to the goals, the target, their needs. As a team in the curriculum committee, we have never rejected any of their request. We do help them.

R: I notice that your resource centre is quite well equipped and I also see a number of sets of science books. However some of the pupils were telling me that they always borrow story books only from the library. When I showed them the science books, they seemed very interested. I am just wondering whether the teachers could bring the pupils to the library, thus encouraging them to look for information and creating an interest in reading science books.

PN. DORIS: The problem is the time factor. Unlike the secondary schools, the children here have to

(S1:HT:P1)

follow a very rigid timetable as you would have noticed. Once the regular school time is over, the parents are here to take them. Unlike secondary schools where they stay back after school or in secondary schools, they do not take certain subjects and they can go to the library. Here the children take all subjects. The only alternative as you know is the Islamic studies and moral education. Even then it is not a free period for anybody as they have to go to one or the other. That is the problem. A period a week is allocated for them and also during the recess time. The recess is so short.

R: I also notice that you have facilities like TV, video.

PN. DORIS: We have, but at the moment, it is not working.

R: Most of the teachers that I talked to do not make use of education TV program. Why do you think the teachers are not using them?

PN. DORIS: Many years back, I encouraged the teachers to do so. But the problem was and is I think what is being viewed through education TV is sometimes well behind the syllabus. If we have to follow the education TV as should be, the teachers will not be able to finish the syllabus within the year. As you know, the system in Malaysia is more on examinations. They have got a fixed syllabus to finish within the year and they have an exam to sit. What we have done because we have been provided with the timetable of what topic would be shown on certain days. If the teachers feel that certain topics are good, the resource teacher would tape it. We would love to have the children sitting to watch those programs.

R: It would be a good idea if the state resource department could dub the tapes and send them to schools, the teacher could choose what they feel are suitable and show them during the lessons.

PN. DORIS: That would be better.

R: I talked to the students, they were telling me the nice discovery programs on the Astro TV (TV channel). I was suggesting to the teacher if the school can provide some empty cassettes, I think many of your pupils would not mind to record and can use it for the class. It takes a bit of initiative from the teacher. Most of the teachers in your school are only teaching one or two subjects. Why do you prefer specialisation?

PN. DORIS: Because I found through my years as the head of the school and also my experience as a teacher for about thirty years, when a teacher specialises on a certain subjcct, thcy arc better teachers. Rather than you asks them to teach five subjects, they have to prepare for five subjects. The teachers in the schools are give two subjects, at the most three. They will be strong in the content. Even though they do not have specialised training like the secondary teachers, I feel that it is better. It is easier for the teachers.

R: What are some of the constraints that you face in providing support to the teachers?

PN. DORIS: Classroom. Even though we have got the science laboratory, sometimes because of the shortage, the science room has to be used as a classroom especially in the afternoon. Some teachers would like to give extra classes in the afternoon. They cannot do it.

R: I understand that the education department provides the equipment for the science lab. The teachers mention that they are not quite enough and some others were not supplied. Does the school have any allocation to help to supplement those things?

PN. DORIS: We do have. If the teachers after the meeting and they really feel that the equipment are needed, not enough, all they have to do is to ask. We will decide according to the priorities. We have so many subjects. Because science has only started three years, we have done our best so far.

R: Do you drop in to see teachers teaching?

PN. DORIS: We are required to do so. I think you are aware of the system of assessment. We are required to say for instance, a semester, the senior assistant he has to go at least three times and myself also. We do enter. But if you are talking about these few months, we have been very busy with the sports and what not. We have not been able to do so.

(S1:HT:P2)

R: Overall, what would you say about your teachers?

PN. DORIS: There is much to be improved. As I said, I cannot blame them because they are not science teachers. I did science when I was in school. I can see a lot has to be improved. I cannot blame them because they are not science students. We did have a few teachers who were science students when they were in school. Unfortunately they took up English as an option as English was their best subject. The requirement is that they have to teach English and they prefer to teach English. There is another teacher who was a science student but she has specialised in Mathematics and she is a very good mathematics teacher and has been teaching mathematics for many years. Science, being a new subject, we make use of whoever is available.

R: Do you think teaching science is different from teaching other subjects?

PN. DORIS: It should be in a way because I mean the fact that a science laboratory has been specially put up even in primary school. It should be a different method. The children should make use of the things during the experiments whereas like languages, it is different. They will be making use of the radio.

R: When they teach about animals and plants, would you expect your teacher to bring in some specimens for study in the lesson.

PN. DORIS: I would expect. I have told them. I would expect them where possible. It would not be at the same level as what is being done in the secondary schools.

R: How is the workload of science teachers compared to other teachers?

PN. DORIS: More or less the same.

R: What do you see as the characteristics of a good science teacher?

PN. DORIS: First the teacher must be interested in the subject and she must be self motivated, initiative and innovative - all these. I feel that a science teacher should not wait for directive from anybody. For instance, if they need certain equipment, if they need certain specimens, they have to go and look for it, ask for it rather than wait. It comes to initiative. If they are not interested, it will be a burden. It will not be a joy teaching the children. Somehow, the feeling will be passed on to the pupils.

R: In your resource centre, you also have a special room for teaching aids where there are quite a lot of charts.

PN. DORIS: Some are supplied by the education department. The others are bought by the school. We just wait. They have the curriculum meetings.

R: Are slides readily available? Any salesmen coming to promote the product?

PN. DORIS: No. Only kits and charts.

R: The problem then is the lack of software.

PN. DORIS: That is right.

R: Do you feel the department should give more support to the school?

PN. DORIS: I have no complaint at the moment considering that this subject is new in the primary school. If we hope to perform well, of course we need the support especially in providing the right equipment, the right aids. Maybe my school is in a better position whereby we can get some support from the public where money is concerned. I would view other schools in the outstation that it is difficult if they are not given support from the department.

Researcher thanked the head teacher and wished her all the best in continuing the good work that she has been doing.

(S1:HT:P3)

Appendix J
Letter to the Research Participants Requesting Feedback on Report Findings

14 Carow Street
Palmerston North
New Zealand

July, 1998

Dear ,

I am sending you a report of the findings from the study that you participated during March to April, 1997. Please read through it carefully. If you think that the report reflects your thoughts and your teaching practices fairly accurately, please say so. If there are any statements in the report that you do not agree with, please complete the enclosed feedback form by:

i. writing the page number and the line number showing where these statement are found in the report, and
ii. explaining briefly why you do not agree.

You can write in English, Chinese, or Bahasa Malaysia.

Please send the completed feedback form to me using the self-addressed envelope enclosed. This will enable me to modify those sections that you wish to alter before this report is included in my thesis. Thank you.

Yours sincerely,

Jeannie Ling Ai Yieng

Feedback Form

1. Do you think the report of the findings of the study reflect your beliefs, thoughts and teaching practices fairly accurately? Give your comments.

2. Please identify the statements in the report that you do not agree with and briefly give your reasons for not agreeing.

i. Page number: Line number:

Reason for not agreeing:

ii. Page number: Line number:

Reason for not agreeing:

iii. Page number: Line number:

Reason for not agreeing:

Appendix K
Sin Hwa School Scheme of Work for Primary Four Science, 1997

Week	Date	Holiday	Content	Test Content	Date for test	Teacher in charge
1	6.1-10.1		Lesson 1			
2	13.1-17.1		Lesson 2			
3	20.1-24.1		Lesson 2			
4	27.1-31.1		Lesson 3			
5	3.2 - 7.2	5.2-16.2	Lesson 3			
6	17.2-21.2		Lesson 4			
7	24.2-28.2		Monthly test 1	Lesson1-4	25.2	A
8	3.3-7.3		Lesson 5			
9	10.3-14.3		Lesson 6			
10	17.3-21.3		Lesson 7			
11	24.3-28.3	28.3	Lesson 8			
12	31.3-4.4		Monthly test 2	Lesson 5-8	1.4	B
13	7.4-11.4		Lesson 9			
14	14.4-18.4	18.4	Lesson 10			
15	21.4-25.4		Lesson 11			
16	28.4-2.5	1.5	Oral exam (for languages)			
17	5.5-9.5	8.5	Semester exam	Lesson 1-11		Head
18	12.5-16.5		Lesson 12			
19	17.5-21.5		Lesson 13			
	22.5-8.6		Holiday			
20	9.6-13.6		Lesson 14			
21	16.6-20.6		Lesson 15			
22	23.6-27.6		Monthly test 3	Lesson 12-15	24.6	C
23	30.6-4.7		Lesson 16			
24	7.7-11.7		Lesson 17			
25	14.7-18.7	17.7	Lesson 18			
26	21.7-25.7		Lesson 19			
27	28.7-1.8		Monthly test 4	Lesson 16-19	24.7	D
28	4.8-8.8		Lesson 20			
29	11.8-15.8		Lesson 21			
30	18.8-22.8		Lesson 22			
31	25.8-29.8		Lesson 23			
32	1.9-5.9	1.9	Monthly test 5	Lesson 20-23	2.9	E, F
33	15.9-19.9	16.9	Lesson 24			
34	22.9-26.9		Lesson 25			
35	29.9-3.10		Lesson 26			
36	6.10-10.10		Revision			
37	13.10-17.10		Revision			
38	20.10-24.10		Oral exam			
39	27.10-31.10	30.10	Examination	Lesson 12-26		Head
40	3.11-7.11					
41	10.11-14.11					
42	17.11-21.11					
		22.11	Holiday begins			

Appendix L

Suggested Activities on 'Animal Reproduction' in the Teacher's Guide

(Khor, 1994b)

1. Pupils observe the picture on page 32 of their textbook. Teacher gives the pupils opportunity to realise that animals have young ones.

2. Teacher explains that animals can reproduce. Pupils give reasons why animals need to reproduce.

3. Teacher tells the pupils that animals reproduce under favourable conditions. If conditions are not favourable, they do not reproduce, the number becomes less and less and finally they will become extinct.

4. Pupils discuss how they could protect the endangered species of animals.

5. Teacher leads pupils to observe how common animals like chickens, dogs and cats look after their young ones and why they take care of their young ones.

6. Teacher tells the pupils that the baby animal grows in the mother's body for a certain period of time before being born and this way of reproduction is known as giving birth.

7. Pupils observe the picture on page 33 of their textbook, name the animals and say the number of newly born animals of each type of animals, that is human, cows and cats. Compare these with other types of animals. Pupils will conclude that the number of newly born animals varies.

8. Teacher discusses with pupils whether all newly born animals can move on their own. Pupils give examples of animals whose newly born babies can move on their own and those animals whose newly born babies cannot move on their own. Pupils can divide animals into these two groups.

9. Teacher explains the difference between eggs with shell and eggs without shell. Pupils give examples of both types of eggs. Teacher tells them that the female animals lay eggs and eggs hatch into the young ones. The animals which reproduce in this way are animals which lay eggs.

10. Pupils look at the picture on page 34 of the textbook and give more examples of animals that lay eggs.

11. Pupils discuss those animals which lay eggs on land and those that lay eggs in water.

12. Teacher questions the pupils on whether their parents look after them. Pupils give examples of animals who take care of their young ones and those who do not take care of their young ones.

13. Pupils look at the pictures of animals on page 35 and describe the appearance of the young ones of butterfly and frog.

14. Teacher explains the various developmental stages of animals like butterflies and frogs, and that the young ones of these animals do not resemble their parents. Only when they mature, they resemble their parents.

15. Pupils give examples and explain those animals whose young ones resemble their parents and those animals whose young ones do not resemble their parents.

16. Pupils classify animals into (i) those give birth and those lay eggs; (ii) whether they look after their young ones; and (iii) whether the young ones resemble their parents. Pupils can use pictures to illustrate these.

Appendix M

Objectives of 'Animal Reproduction' in the Teacher's Guide

(Khor, 1994b)

1. Pupils can explain the purpose of reproduction.

2. Pupils can explain the meaning of animals that giving birth.

3. Pupils can give examples of animals which give birth.

4. Pupils can explain the meaning of egg laying animals.

5. Pupils can give examples of animals which lay eggs.

6. Pupils can explain that some animals look after the young ones.

7. Pupils can give examples of animals which look after the young ones.

8. Pupils can explain that new borns of some animals resemble their parents.

9. Pupils can explain that new borns of some animals do not resemble their parents.

10. Pupils can give examples of (8).

11. Pupils can give examples of (9).

12. Pupils can classify animals into animals which give birth and which lay eggs.

13. Pupils can classify animals into those which take care of their young ones and which do not take care of their young ones.

14. Pupils can classify animals into those which the new borns resemble their parents and which the new borns do not resemble the parents.

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