Re-defining Teacher Education of Primary Teachers of Science in Hong Kong

A thesis
submitted in fulfilment
of the requirements for the degree
of
Doctor of Philosophy
at the
University of Waikato

by

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The University of Waikato
2000

Abstract

This study arises from my personal interest as a lecturer in the Hong Kong Institute of Education with a responsibility to prepare student-teachers to teach science at the primary level. This study was conducted based on three concerns about science and science teacher education in Hong Kong. Firstly, there are concerns about the quality of science teaching in local schools. Secondly, other local studies concluded that the majority of both primary teachers and student-teachers come from an arts education background in their secondary schooling and that they lack the confidence to teach science topics. Thirdly, teacher educators are concerned about the low impact of teacher education programmes, as the school culture seems to have an important influence over classroom practice. In the present study, the researcher attempted to address these problems by finding out ways to better prepare the student-teachers for teaching primary science, and to understand more about the process of learning to teach, by describing the professional, personal and social development of the novice teachers. Drawing on the findings, science educators can be better informed about how to prepare the student-teachers professionally, and increase their confidence in science teaching. Furthermore, with a picture on teacher development, practices that are conducive to teacher development can be identified and hence better support for the novice teachers can be designed.

In the present study, the constructivist view of learning was applied to inform science teaching in the primary classroom, and the sociocultural view of learning was used to explain the development of novice science teachers in the process of learning to teach. The literature on the scoiocultural view of learning, teacher development, teacher socialization and knowledge about teaching provided a framework for the present study. Drawing on the literature about a sociocultural view of learning, learning in the teacher education programme had to be re-contextualised in the primary classroom. The teacher educator was seen to be an agent, with the purpose of mediating between the novice teachers and the teaching culture that is informed by a constructivist view of learning. Drawing on the literature about teacher education, teacher educators need to acknowledge the past learning experience of the learners, to practice what they preach and provide experiences that increase the learners' confidence in teaching science. They have

to be aware of the possible influences of the school context on the teachings of the novice teachers, and to provide continual support during the beginning teaching phase. They have to be knowledgeable about the various aspects of teacher development namely, professional, social and personal development. The novice teachers have an active role to play in the learning process and have to be involved in active discussions with their peers during the learning process. Instead of viewing novice teachers as passively adapting to the school requirements, they can be active agents that may lead to changes in the practice of the school or the experienced teachers.

This was a two-year study that followed the development of the same group of student-teachers during the teacher education programme to the time after their graduation and continued until the end of their first year of teaching. This study included three phases. The first phase involved the implementation of the Curriculum Studies Module in the teacher education programme. The Module introduced a range of science teaching approaches in which there was an emphasis on teaching science based on a constructivist view of learning. The student-teachers were interviewed before and after the Module. These interviews were to find out if there were changes in the views of the student-teachers on science teaching and learning.

The second phase was the teaching practice phase. During this period, the student-teachers were observed in their lessons and there were interviews to find out whether the Curriculum Studies Module had influenced their teaching and their views of learning.

The third phase is the beginning teaching phase. This phase included interviews with the beginning teachers three months after they started their first teaching assignment. These interviews provide a background on how the support for these beginning teachers in the form of resource packs should be designed. The support included the provision of a resource pack, an introductory workshop and personal support from the researcher. The resource pack included suggested topic sequences, information about children's preconceptions and suggestions for activities. During the implementation of the resource packs, the beginning teachers were observed in their lessons and were interviewed. These aimed to find out whether the support in the form of the resource packs, the interactions with the researcher, and the interactions with teachers in the school (if any) had an influence on their views of teaching and learning.

The data in the three phases were analysed in order to build a picture about the professional, personal and social development of the student-teachers or the beginning teachers.

Findings suggest that the student-teachers experienced a gain in their confidence in teaching science after the Curriculum Studies Module, and were able to teach with a constructivist view of learning in their teaching practice which was at the end of phase two. However, as the graduates started on their first teaching assignment in phase three, they were often unable to practice what was taught in the module in their science classes. With the support of the resource pack and the researcher, the science teaching of the beginning teachers was more consistent with a constructivist view of learning and some were even able to influence their colleagues to give more thought to their science lessons. It appears that these interventions had facilitated the novice teachers to teach science with intentions consistent with a constructivist view of learning; to perform the teacher actions that help to engage pupils in thinking in the lessons; to develop better learning outcomes and learning conditions as well as experience gains in their confidence in teaching science.

Drawing on the findings, the study concluded with a dynamic model on teacher development that emphasizes the interactions between the novice teacher with the institutional culture and those with the school culture. From a sociocultural view of learning, teacher development is seen as a contextualised activity and recommendations for teacher educators were made.

Dedication

This thesis is dedicated to my parents for their love and encouragement. It was they who inspired in me an interest to study and to pursue higher education.

Acknowledgements

I would like to acknowledge the support from the Hong Kong Institute of Education that provided me with the funding and the study leave to pursue my study. I must thank the student-teachers who participated in the study. I also thank my colleagues at the Institute who have tolerated my absence and taken up heavier responsibilities as I was taking my study leave. In particular, I would like to thank Prof. Cheng Yin Cheung and Dr. Francis Cheung for their kind encouragement at various stages of my study.

I must pay tribute to my three supervisors who have provided great support during my course of study. I have enjoyed the inspiring discussions with Associate Professor Beverley Bell whose importance can be compared to that of a lighthouse for a ship sailing in the dark sea. I thank Dr. Alister Jones and Dr. Miles Baker for their great professional support and encouragement. Apart from my supervisors, I would like to thank Ms Raeywn Outlon for her great patience and tolerance whenever my computer was not working properly and on numerous other occasions related to the printing, fax and photocopying etc.

I thank my husband, Andus Lai and my child, Gavin Lai for their tolerance over my mental and physical absence while I was concentrated on my study. In particular, Andus for taking sole responsibility for our child during my physical absence. Postgraduate students at the Centre of Science, Mathematics and Technology Education Research are also like members of my family in terms of the way we support each other in the course of our study. Finally, I must acknowledge such support from Wheijen Chang, Teresa Frenendaz, Kun Hsien Tsai and Kai-ming Li.

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Chapter 1

Introduction

This study arises from my personal concern as a teacher educator to provide better preparation for student-teachers in the area of science teaching. This chapter summarizes the background of primary science teacher education in Hong Kong, my concerns and why the research was undertaken.

1.1 Primary science teacher education in Hong Kong

Teacher education in Hong Kong underwent a major reform in 1995 when the new Hong Kong Institute of Education was established. The former Colleges of Education, which had existed for over 30 years, were replaced and amalgamated. Initial teacher education programmes were restructured with the aim of upgrading the quality of teacher preparation. At the pre-service level, the Institute offers a two-year and a three-year Certificate of Primary Education programme. The entry requirements for the two-year group is set at university entrance equivalence, whereas the three-year group is set at a lower level. The first year in the three-year programme is meant to be a foundation year to raise the students' academic standard. This group of student-teachers joins the two-year group in their second year of study. At the end of the programme, both groups obtain the same certificate.

The Certificate of Primary Education programme prepares students to teach three to four subjects in primary school namely, Chinese, Maths, General Studies (an integration of Science, Health Education and Social Studies) and one other elective subject. Students can choose Science, Social Studies, Arts, Music, Physical Education, English or Putonghua (Mandarin) as their elective subject. The curriculum of the certificate programme was designed to meet the demands of local primary schools, where all the teachers are expected to be capable of teaching Chinese, Maths and General Studies. All the students in the certificate programme will study a module on science academic knowledge, which aims to raise their understanding in areas particularly related to the topics in the General Studies curriculum. The content of this module for the science and the non-science group is different, taking into consideration their previous secondary education background. Most of the non-science students are quite confused with the contents in the module and have much difficulty in understanding the concepts. In my experience, many of the science elective students find the module content not directly relevant to their teaching in the primary school and too difficult.

Although all the student-teachers are prepared to teach General Studies, of which at least one-third consists of science elements, it is doubtful if they are all confident and competent in teaching them. As science is offered as an elective and admits students with science to secondary 7 level, the science elective students are expected to be more competent in teaching the science topics. When they graduate, these Science elective students are expected to take a leading role in the school, as they are more familiar with the new curriculum and have an adequate science background. However, the reality is that when all the students graduate, regardless of their elective and secondary school background, they have to teach General Studies, which contains science topics, in a primary school. In view of this need for a better preparation in teaching General Studies for all the students, there was an attempt to restructure the programme in 1996. Science was also offered as an elective to the Social Studies elective students. This means that this group of students who do not have science at secondary 7 level are also admitted as science elective students, and this allows them to take an optional module called Curriculum Studies which prepares them to teach science topics in the General Studies subject. The module on Curriculum Studies in the science elective develops their teaching skills, introduces teaching approaches, and provides the opportunity for micro-teaching in science topics. Most of the science elective students give positive comments about this module.

The science elective students, like all the other students in the programme, have a chance to teach General Studies in both their year one and year two teaching practice. There are 4 weeks of teaching practice in the first year of the two-year programme and 8 weeks in the second year. Usually, the students have at least one opportunity to teach General Studies. However, due to the structure of the

General Studies curriculum, they may or may not have a chance to teach science related topics. During the teaching practice, they have a chance to test out the theories learnt, to have peer observation and in the first year to be under the guidance of a co-operating teacher. The teaching practice provides an opportunity for the student-teachers to test out the strategies that they have learnt in the programme.

1.2 Primary science education in Hong Kong

The subject of primary science, which was taught for more than fifteen years, was replaced by an integrated curriculum, General Studies, in 1995. There are debates on the advantages and disadvantages of subject-separation against subject-integration (Carin, 1993; Koballa and Bethel, 1991). The arguments rest on the belief of the purpose of science education at primary level. One of the basic aims of teaching science separately is to let pupils learn, from an early age, how scientific information is obtained, and how it relates to evidence. Arguments supporting integration suggest introducing science more naturally, which assists pupils' understanding of the environment. It is mentioned in the syllabus for Hong Kong General Studies (Primary I-VI) (1994) that through meaningful activities children understand the inter-relationship and interdependence between people, things and their environment, brought about by modern scientific and technological advancements. This integrated approach claims to allow pupils to look at issues from different perspectives, hence making their learning experiences more holistic and less fragmented (Curriculum Development Committee, 1994). However, teachers who feel insecure and incompetent in the area of science experience great difficulty in teaching the integrated curriculum (So, Cheng and Tsang, 1996).

1.2.1 An account of a "typical" primary science lesson in Hong Kong

The concern for the quality of science teaching is realistic when science lessons in Hong Kong are typically dominated by teacher-talk, with few opportunities for hands-on practical activities. Based on my experience as a teacher educator, the primary teachers have a heavy reliance on the textbook and the accompanying teachers' guide. Very often these are the sole source of information on which the teaching is based. On average, the teachers are occupied in class teaching for about 80% of the school hours and there is very little time left for lesson preparation. There is also a lack of science teaching resources in the school. Most of the resources are provided by the publisher of the textbook, which may include transparencies, wall pictures and CD Roms. However, as teachers have little time for preparation, they may not even have time to find out if these resources are suitable for their teaching. In teaching science topics, the teachers are concerned mostly with covering the text in the textbook and getting pupils to complete the relevant exercises in the workbook.

Practical activities are rare due to the limited time for lesson preparation, lack of resources and the restriction of the small size of the classroom with a large number of pupils. Many teachers rely on Educational Television to show pupils the practical activities. Educational Television programmes are prepared for a number of subjects including Chinese, English, Mathematics and General Studies. The programmes cover the contents from primary three to six. The pupils may watch the programmes at home or at school, and thus they may know all the content before a certain topic is taught. In most of the schools, there are about five lessons per week for General Studies and the teachers will devote one of them to watch an Educational Television programme.

A typical science lesson is illustrated by the observation of one of the student-teachers' lessons in his first job. As the teacher was one of the student-teachers in the present study, he understood what is meant by teaching based on a constructivist view of learning and was influenced by the experience of the Curriculum Studies module. Hence, the account may still vary from the "typical", although the practice was found to be close enough to what teachers usually do in the science lessons in Hong Kong.

The topic was plants and the pupils were in primary four at age nine to ten. There were about 30 pupils in the classroom with all of them sitting in rows facing the teacher. The teacher started the lesson from where he had stopped in the previous one:

> T: Yesterday we were talking about plants living in different places having different characteristics. Does anyone remember why they are different?
> (There was no response for about 1 minute.) Teacher repeats the question.
> T: What are the factors that make them different?
> P: Weather and season.
> T: It is correct to say weather but they may not be different in different seasons. There is one more factor.
> P: Soil and nutrients.
> T: Soil and nutrients have some effect but are not the major factors. There is one more factor, which is more important.
> P: Temperature.
> T: Temperature, there is one more factor.
> P: Rainfall.
> (Ebo1) (For a description of the coding, please refer to Chapter 3, section 3.4.2.)

The pupils had a habit of remembering the key points or key words in the topic, as this is important in examinations. The teacher introduced the development of the lesson by asking the pupils to refer to the textbook:

> T: Temperature and rainfall affects which species of plant can grow and the way they live. Different types of plants live in different places. How do plants adapt to the environment? Look at the pictures in the book and see how the plant structures adapt to the environment.
> (Silence as pupils look at the pictures.)
> What type of tree is that?
> P: A deciduous tree.
> T: Will the tree shed its leaves in autumn?
> P: The leaf is dry.
> T: Why did this happen?
> P: There is less water in autumn and there is less rainfall. The leaves are shed to prevent the plant from wilting.
> (Ebo1)

Teaching based on the content of the textbook is common as is the fact that the teacher made use of the pictures in the textbook to guide the discussions. However, the pupils were keen to find out the answers to the teachers' questions by reading the text:

> T: (Repeats the answer) Yes, that is correct. This decreases the area of surface that is exposed to air and so decreases evaporation. Besides this, there are other ways, in autumn; not all the trees shed their leaves. Let's look at other examples. What is special about pine trees?
> P: The leaves are sharp. This decreases the evaporation.
> T: Do not just read the words, look at the picture of the leaves, how are they different from normal leaves? What do they look like?
> P: They are in the form of spikes.
> T: Yes. Don't just read the words, you can also find the answer from the pictures. What is the advantage of being needle shaped?
> P: This is another way of decreasing water evaporation.
> (Ebo1)

The teacher attempted to encourage pupils to observe the pictures and think about the implications of the characteristics of a plant. The pupils were keener to read directly from the textbook. The lesson continued in this manner for the whole 35 minutes. There were questions from the teacher, pupils' answers, and pupils observing the pictures, and in the process a few pupils raised questions about the adaptation of plants.

This lesson was close to a "typical" lesson in that there was no group activity for the pupils, and teacher demonstration was rare, although this is more likely to happen than group activities. Very often there is no pupil discussion in groups. The pupils and the teacher rely a lot on the textbook, almost as the sole source of information. This lesson is different from a typical one in that the teacher asked challenging questions that stimulated pupils to think, he encouraged them to observe closely and there were also pupils asking questions from time to time. This can be interpreted as the influence of the Curriculum Studies module in the teacher education programme which had emphasized teaching science based on a constructivist view of learning.

1.3 Beginning Teachers in Hong Kong

In Hong Kong, the induction provision of beginning teachers is not widely undertaken in schools (Cooke and Pang, 1991; Chan, 1996). As reported in a recent study of secondary schools (Cooke and Pang, 1991), only 15% of the teachers who participated in the study had experienced some form of induction provision. The Education Commission Report No. 5 (Education Commission, 1992) has recommended a systematic induction programme in secondary schools, and has also recommended that one of the assistant principals in the school should be responsible for arranging support for novice teachers. The situation in the primary schools is largely unknown, and a unified induction policy is absent in primary schools. Mentoring is still at an experimental stage in primary schools (Chan, 1996). It can be expected that novices are left on their own and that support from schools is limited, if not non-existent. While there may be informal support from the more experienced teachers for the novices, the induction provisions are not mandatory in schools, and a formal system has yet to be set up.

At present, graduates of the Institute of Hong Kong become qualified and registered once they have successfully completed the Certificate in Education programme. After the student-teachers graduate, the schools are the only parties that evaluate the teaching performance of the teachers. Even if their work is unsatisfactory during the 2-year probationary period, they may lose their job but not their license to teach, although situations such as this occur very rarely. As a result, it is doubtful if the quality of teaching is maintained or enhanced after the teaching position is secured.

1.4 The Problem

There are three problems that have motivated the researcher to conduct the present study. The first problem is related to the quality of science teaching, which in turn may influence pupils' achievement. According to the results of the Third International Study on Science and Mathematics Achievement, the achievements of Hong Kong students in science were very different from their achievements in mathematics at the grade eight standard (Law, 1997). They ranked 26 among the 44 participating countries in Science, while in Mathematics Hong Kong was among the highest 4 in the list. The situation was more worrying when the results of the Second International Study were considered. Science achievement for the primary 6 and the lower secondary students in Hong Kong was one of the lowest among the 22 participating countries. It is a major concern among local science teacher educators that students' achievement in science is low by international comparisons. There is therefore a quest to improve science learning and teaching in primary schools. The data collection for the Third International Mathematics and Science Study (TIMSS) was completed in 1993, while the new integrated General Studies curriculum was introduced in 1994. Although little is known about the effect of the new integrated curriculum on the science learning achievements in primary schools, the situation is not expected to improve. The lack of planning for lessons and inadequate resources in primary schools aggravate the problem. The quality of science teaching at the primary level is of great concern for local science educators. Improving the quality of the initial teacher preparation programme is one of the attempts that may help to raise the quality of science teaching in primary schools.

The second problem is associated with identifying ways of improving the current teacher education programme in relation to the preparation of primary science teachers. This does not seem to be an easy task due to the problematic context of teacher education in Hong Kong, where the majority of the student-teachers have an arts background in their secondary education (Cheng and Pang, 1997; Cheng, 1997). Teaching science has already been found to be difficult enough for student-teachers with an adequate academic background suggested by a study of beginning teachers with a science background at pre-university level (Cheng and Pang, 1997). In the findings of the study, the novices reported more on the teaching intentions they were unable to achieve, rather than on those they could achieve in their science lessons. Some of the respondents even described most of their lessons as "talk and chalk", and although some attempt to stimulate students to think was made, they had little success in getting the students to engage in thinking.

Science is taught in an integrated curriculum at the primary level, and all teachers, regardless of their previous education background in science, are required to teach the subject. The initial teacher education programme is charged with the responsibility of improving student-teachers' academic knowledge in science as well as pedagogy. A study of student-teachers' perceptions of primary science teaching (Cheng, 1997) revealed that the non-science elective student-teachers (those with science at secondary two level) faced much greater difficulty in their teaching practice than the science elective student-teachers (those with science at secondary seven level). Their views of science teaching were largely inadequate, as some equated science teaching to doing experiments, and their major concern was whether the practical activities worked or not. Unlike the science elective student-teachers, they did not consider safety issues, or pupils' abilities and previous knowledge in planning their lessons. Moreover, the student-teachers found that the academic studies module in the teacher education programme repeated their negative experience of science learning during their secondary schooling, instead of raising their academic standard in the subject. This suggests that the teacher education programme was inadequate in preparing student-teachers to be competent and confident in teaching science. There must be efforts to identify ways of improving the current practice of preparing teachers to teach primary science in the initial teacher education programme. In particular, ways to support the non-science student-teachers need to be identified. This is because the non-science group makes up the majority of the student-teacher population, as out of a total intake of 500, approximately only 40 to 60 student-teachers have science up to pre-university standard. If the quality of science education is to be improved, ways of preparing the majority of the student-teachers to teach science needs to be considered.

The third problem is associated with developing the classroom practices of the student-teachers and beginning teachers. Although teacher educators may strive to improve the quality of their teacher education programmes, these programmes may have little influence on the classroom practices of the student-teachers. Researchers (Calderhead and Robson, 1991; Zeichner and Gore, 1990) explained this as student-teachers having preconceptions about teaching based on their learning experience, and that these "role models" are not easily replaced by education and teaching units in the teacher education programme. While the preconceptions of the student-teachers may be a concern, Cater (1990) suggested that "school-based socialization accounts for the low impact of teacher education". Moreover, researchers (Olson and Osborne, 1991; Etheridge, 1989) are concerned about developing an understanding about how the cultures of the school and the teacher education institute influence the novice teachers in their learning process. Hence, apart from identifying ways to improve the initial teacher education programme, the teacher educator needs to identify the needs of the beginning teachers and support them in their beginning teaching. The result of these two attempts may eventually lead to an improvement in the quality of science teaching in schools eventually.

Given the situation that the quality of science teaching is a concern in Hong Kong, that the quality of the initial teacher education has to be improved, and that ways to support beginning teachers have to be identified, it is important that teacher educators (i) devise strategies that can better prepare the student-teachers to teach science in primary schools and (ii) understand more about the process of learning to teach among the student-teachers and the beginning teachers.

1.5 An overview of the thesis

Having described the problem and aim of the study in this chapter. The second chapter is a literature review outlining studies and theories on the constructivist and sociocultural views of learning. Based on a constructivist view of learning, implications for science teaching are also explained. Studies on teacher development models and teacher socialization experiences are described. The literature forms a basis from which teacher development is defined and analysed. Chapter Three describes the method of the study, including the intervention strategies, the data collection and data analysis. The prior views about learning and teaching among the student-teachers are described in Chapter Four. Chapters Five and Six portray the learning experience in the Curriculum Studies module and the teaching practice respectively. Chapter Seven analyses the needs of the beginning teachers as they enter into teaching, and presents the two resource packs which were designed based on these needs. Chapter Eight reports on the implementation experience of the beginning teachers, and depicts the learning process during beginning teaching. Chapter Nine attempts to theorize the findings of the study and describes learning to teach as a sociocultural activity. Chapter Ten concludes the study, and the implications for teacher education and further research are drawn.

Chapter 2

Literature Review

2.1 Introduction

The present study looked at the process of teachers learning to teach as student-teachers and beginning teachers. Therefore, the novice teachers were seen as learners. Teacher educators have examined teachers' learning from different perspectives, namely, learning theories that explain teacher learning, the knowledge to be learnt, the type of teaching teacher educators hope teachers will learn, and the type of teaching that was learnt (Feiman-Nemser and Remillard, 1993). In the Teacher Educator's Handbook (Feiman-Nemser and Remillard, 1993), teacher learning from each of the perspectives is analysed, the implications for teacher educators' practice in facilitating the task, knowledge and dispositions to learn are drawn, and the processes and opportunities to learn are identified. Borko and Putnam (1996), in looking at teacher learning from a cognitive psychology perspective, developed an analysis of teachers' beliefs and knowledge, and ways to change them, how the learning is influenced by the school culture, and ways to support teacher learning. There are studies on more specific forms of teacher learning, for example Kennedy (1998), who examined how teachers learn to teach writing. The study reported on teachers' experiences as learners, emphasizing the importance of longitudinal studies that investigate teacher learning, and concluded by defining teacher learning as the transformation of beliefs.

While the present study looked at teachers as learners and describes their development, this chapter draws on the literature to identify studies in three areas:

- Views of learning
- Science teaching
- Teacher education for science teachers

In the first area, the implications of constructivist and sociocultural views of learning for science education and teacher education are considered. The sociocultural view of learning is relevant for analyzing teacher development or teacher learning while the constructivist view of learning informs the teaching of science. The second area examines the meaning of teaching science based on a constructivist view of learning. In the present study, the student-teachers were prepared to teach science based on a constructivist view of learning. The third area defines the practice of teacher educators to prepare student-teachers to teach based on a constructivist view of learning. These strategies mainly inform the design of the interventions of the present study. Further, the relationship between science teaching efficacy beliefs and teaching confidence is explored. This area relates to the development of the student-teachers in terms of their confidence to teach science based on a constructivist view of learning. The third area also provides a review of the different models of teacher development and studies of teacher socialization. Finally, this chapter includes the aims that guided the present study, and the research questions are listed.

2.2 Views of learning

This section describes two views of learning that may inform both science teaching and learning, as well as teacher development. Given that teacher development may be seen as teacher learning, there are commonalties between the processes of learning and learning about science teaching. The two views of learning reviewed in this section are the constructivist view and the sociocultural view. The former is relevant in the present study for helping the student-teachers to teach based on a constructivist view of learning, and the latter provides a background to understanding the process of learning to teach.

2.2.1 Constructivist views of learning

The basis of a constructivist view of learning is that learning is effected by an individual when a mental representation of an object, event or concept is formed or constructed. Resnick (1991) suggested that mental representations which can both enable and constrain individual learning, are a basis for mental and physical actions. The following review looks into four categories of constructivist views of learning, namely, Piaget's approach (Piaget, 1970), the personal construct psychology approach (Kelly, 1969), personal constructivism (Osborne and Wittrock, 1985), and social constructivism (Bell and Gilbert, 1996). The discussion touches on each of the views briefly, and implications for the learning of science and science teaching are drawn.

Piaget's approach is characterised by the view that knowledge is constructed by the cognition of the individual, and the process by which the person constructs the knowledge of the world is of central concern (Piaget, 1970). The process of learning is described as equilibration. The individual assimilates new information into the existing mental structure, and if the process of assimilation fails, the information will be accommodated in a modified form or the mental structure is modified. These processes of assimilation and accommodation were referred to as equilibration, which was seen as an essential process in learning. Moreover, Piaget conducted research programmes that aimed to look at an individual's cognition through the development of content-independent logical structures and operations, for example, logico-mathematical reasoning. The learning of an individual was dependent on the personal developmental maturity according to the defined stages of development such as concrete and formal operational stages. Although Piaget's perspective can be seen as the root of a constructivist view of learning, there were problems with his perspective as outlined by O'Loughlin (1992). Firstly, both the level with which an individual operates and the world can change, while Piaget's perspective takes a view that the individual can operate at the formal operations level without considering the possible changes in the environment. From a social constructivist point of view, knowledge is socially constructed, and knowing is a dialectical process (Bell and Gilbert, 1996). Instead of adapting to the reality from a Piagetian perspective, the individual is involved in examining the reality critically, and constructs critical visions of the reality. This process empowers individuals to envisage and enact social transformation. Thus, both the knowledge of the individual and the world is changed in the process. Secondly, the content-independent view and the emphasis only on individual cognition are problematic. The emphasis on decontextualized learning, decentration from experience, and rationalizing individual's relationships with the world is criticized. This view ignores the influence of the social, cultural and historical aspects in the learning process, and the place of socially constructed knowledge. However, in theorising about learning, the social aspect has gained an increasingly prominent position. The importance of the dialectical interchange between the individual and the society is now being realised.

The personal construct psychology approach was developed by Kelly (Kelly, 1969, Pope and Gilbert, 1983) who described the individual as a scientist who creates an understanding of the world which is composed of tentative hypotheses about the world. These hypotheses are the composition of the personal construct. Past experiences are explained and future directions are predicted based on these hypotheses or the personal construct. Hence, the physical and social worlds are both compared and explained against the personal construct. While this view of constructivism does not limit the application of the personal construct, changing or unchanging of the personal construct was seen as relying on the individual alone. The social environment was not seen as directly influencing the changes, and interactions between individuals were not necessarily seen as leading to consensus or construction of shared knowledge. This approach was mainly proposed on a personal view of learning with little regard to the social environment or interactions.

The above approaches (the Piagetian perspective and the personal construct psychology approach) argue that learners compare new learning with past experiences, and that new learning is a result of replacing or changing their previous concepts. In a similar perspective, Osborne and Wittrock (1985) described children's science learning based on research on alternative conceptions or "children's science". Their generative view of learning suggested that the learner's prior or existing ideas influence how sensory input is selected, ignored or made use of. Secondly, the sensory input itself has no meaning until the learner actively generates linkage between the sensory input and their prior experiences. Thirdly, the linkages and the process of making meaning out of the input is a personal construction process. The new concept may be tested and applied further. This process of personal construction is an active one in which the learner has to accept major responsibility for the mental activity. The importance of the social aspect in helping the individual to link up existing ideas or prior experiences has yet to be defined.

The above approaches assume a common idea that the existing conceptions of the individual guide the construction of understandings. The learners have prior ideas that may influence their subsequent learning. Learning is forming linkages between what the learner already knows and the new knowledge. Knowledge is actively constructed by the individual, and images of the world are formed as a result of the construction. In personal constructivism, learning is seen as an active process as the individual learner makes linkages between existing ideas and new ones. Moreover, the learner has to assume the major responsibility in learning and mental processes. The individual is seen to have agency, that is he or she can decide or not decide to change their existing conceptions.

As described above, in the personal constructivist view of learning, the influence of the social context on the learning process is not addressed, and that knowledge is seen as personal rather than socially constructed. In attempting to explain science learning, the social constructivist view of learning was developed. Driver, Asoko, Leach, Mortimer, and Scott (1994) described the construction of science knowledge in the classroom and related how the students are socialized into the community of science by the teacher. Apart from learning the concepts, this socialization process involves helping students to communicate and think scientifically. Science knowledge is seen as socially constructed by scientists, and students learn this socially constructed knowledge through interacting with the teacher and their peers. Although science knowledge is seen as personally constructed, this socialization process also involves social mediation through interaction with other learners and the teacher who comes from a scientific culture (Tobin, 1993). Moreover, science educators (Bell and Gilbert, 1996) defined a social constructivist view of learning in relation to teacher development as composed of the following characteristics:

- Knowledge is constructed by people.
- The construction and reconstruction of knowledge is both personal and social.
- Personal construction of knowledge is socially mediated. Social construction of knowledge is personally mediated.
- Socially constructed knowledge is both the context for and the outcome of human social interaction. The social context is an integral

part of the learning activity.

- Social interaction with others is a part of personal and social construction and reconstruction of knowledge. (Bell and Gilbert, 1996, p.50)

This part of the literature review has described approaches related to personal and social constructivist views of learning. The personal constructivist view partially informs the present study by the ideas about learners (school pupils and student-teachers) having prior experiences or ideas that influence subsequent learning. For learning among school pupils, this can be applied when considering the learning of the pupils who hold preconceptions about science, and the learning of the student-teachers who had past experiences in their education. The view about the formation of the linkages between new and old concepts informs the practice of science teachers. Moreover, the importance of pupils accepting active responsibility for their learning is also emphasized in science teaching. For learning among student-teachers, this view is consistent with findings in other studies on learning to teach (Borko. and Putnam, 1996; Kennedy, 1998). These studies suggest that student-teachers come into the teacher education programme with their own beliefs and images about teaching which are accumulated or established through their previous education experiences. These views are changed or gradually transformed during the process of teacher education. Although the theme of constructing or changing their beliefs in teaching is consistent with a personal constructivist view of learning, this explanation provides only part of an account of the picture of teacher learning, as the social aspect of learning is not given full consideration.

2.2.2 Sociocultural views of learning

A fuller consideration of the social aspects of learning is given in sociocultural views of learning where learning can be taken as both an individual and a social activity. The personal constructivist view emphasizes the individual learner in acquiring knowledge and cognitive skills (Anderson, Reder and Simon, 1996). Furthermore, a personal constructivist view of learning also suggests the construction of mental representations of concepts or ideas in the mind of the individual (Resnick, 1991). On the other hand, learning can also be viewed as a sociocultural activity. A sociocultural view considers learning as influenced by the sociocultural context, emphasizing the participation of individuals, the interactions between them, and the construction of knowledge through their interactions (Salomon and Perkins, 1998). This includes the Vygotskian perspective that learning depends on the interaction between the child and the more competent others (Howe, 1996). According to these perspectives, the culture and the social interactions are important parts of the learning. Learning can be seen as a socialization process into a new culture through the use of cultural tools such as signs, languages, and computers.

In order to provide an overview of what is meant by a sociocultural view of learning relevant to this study, the meanings of social learning provided by Salomon and Perkins (1998) are summarized. Salomon and Perkins (1998) proposed a perspective that looks at both the individual and the social aspects, emphasizing the interactions between the individual's mind and the participatory process in the social environment or the culture. They distinguished six meanings of social learning, three of which are of relevance to this study:

i. Active social mediation of individual learning. This refers to the learning of an individual as a result of the active social mediation from another person who may be a teacher or a peer. In this case, the social system or a facilitating social agent helps the individual to come to new understandings.
ii. Social mediation as participatory knowledge construction. Learning is seen as a social process in which knowledge is constructed by the group. Interactions between individuals are important and learning must be considered in the light of the social context in which it occurs (Wertsch, del Río and Alvarez, 1995). Knowledge is considered to be jointly constructed by the participants, and is distributed in the social system. The social processes are a part of the learning process.
iii. Social mediation by cultural scaffolding. In this case, the individual learner is helped by the use of cultural artifacts that may range from books, computers, resource materials and sign systems like speech genres.

The sociocultural view of learning explains learning as a result of mediation.

There are three main emphases made explicit by Wertsch (1991): learning as an individual and a social process, learning involving the interactions between the individual and the society, learning involving human action and learning involving the use of tools and signs. These emphases are summarized in the following suggestion:

> 1) a reliance on genetic or developmental analysis; 2) the claim that higher mental functioning in the individual derives from social life; and 3) the claim that human action, on both the social and individual planes is mediated by tools and signs. (Wertsch, 1991, pp.19)

Wertsch's above suggestion is founded on the three themes that ran through Vygotsky's writings. Mediation is the process of socialization into a culture that involves the use of the tools and signs to shape action (Wertsch, del Río and Alvarez, 1995). These tools and signs are referred to as mediational means and they are "products of cultural, historical and institutional forces" (Wertsch, 1991). The mediational means provide a linkage between individual actions and the cultural settings. For example, human language is one of the widely and frequently used mediational means, it is important in shaping thinking and hence action. Wertsch (1991) related how Vygotsky focused on different forms of speaking in relation to different forms of thinking. Mediated actions involve the use of mediational means as well as the intentions of the individual or agent using them. The mediated action is performed with the influence of both the intention of the agent and the cultural settings which shapes the mediational means. In teacher education, the process of helping novice teachers to learn to teach can be seen as mediation. The use of language, signs and resources that help the novices to learn are the mediational means. These mediational means are introduced with the intentions of the teacher educator through mediated actions. Moreover, the mediational means and mediated actions carry with them cultural meanings. These form a bridge between the novices and the professional teaching culture. The use of mediational means and the performance of mediated actions involve interactions between the teacher educator and the novices.

In explaining how mediational means and mediated actions help individuals to learn, the sociocultural view of learning implies a close consideration of the interactions between the individual and the social system. Perkins (1993) put forward the notion of "person-plus" to explain the learning of individuals. He suggested taking on a person-plus perspective of thinking and learning. That is, we need to consider the person plus the surround. In other words, the social system is taken as one unit, and thinking is accomplished partly by the person and partly by the social surround. He also argued that conventional schools do not seem to emphasize the involvement or facilitation of the surround, and much of the attention is given to the person-solo. This gives rise to the problem of transferring what is learnt in schools to real-life applications. If learning is seen as an activity that belongs to the person-plus, then the teacher will have to find out ways in which the surround can support and form part of the learning of individual learners. When applied to science education, this means looking at ways to enhance pupil-pupil interactions. As pupils learn when they are interacting with each other, teachers need to arrange for opportunities for pupils' discussion, participation in activities such that they may interact. The interactions themselves form part of the learning. In teacher education, this means a consideration of the interactions between the teacher and the school or teacher education institution, or interactions with other teachers in the school, or with other student-teachers in the teacher education institute. In these interactions, the individual teacher or student-teacher may reflect on their own ideas. Learning to teach is thus both a cognitive and a social process. Teacher educators therefore need to arrange for workshops or opportunities for discussions to facilitate the interactions.

Having described how interactions may support and form part of the learning, studies on teacher learning share with the sociocultural view of learning the importance of interaction. In describing learning to teach, Borko and Putnam (1996) summarized the findings of a number of studies on changing teachers' theories of teaching reading. Their summary suggests that by encouraging teachers to formulate their own practical arguments for their pedagogical actions, and by sharing these arguments with knowledgeable others in an in-service workshop, teachers can make their own beliefs explicit, and hence are more likely to exhibit changes in their personal theories of reading. Moreover, Feiman-Nemser, and Remillard (1993) proposed teacher learning in "authentic" activity based on the argument that teacher knowledge is a form of situated cognition. Teacher learning is seen to be socially supported and talking about a topic supporting the learning is also an integral part of the learning. Given the importance of interactions, teacher development activities need to include opportunities for the teachers to interact with each other.

The sociocultural view of learning considers interactions at both a cognitive and a social level. In order to explain how individuals learn, Wertsch (1991) referred to the mental functioning of the individual as intramental actions, while the interactions between the individual and the social system are referred to as intermental actions. According to Wertsch (1991), the importance of the linkage between the individual with the cultural, historical and instructional context was first considered in Vygotsky's late writings. He urged that actions be analysed as belonging to both the individual and the social. Individual actions are seen as a component of the social. Moreover, the development of the individual actions influences the social, and vice versa. In teaching and learning situations, the interactions between the teacher and pupils as well as those between the pupils themselves can be considered as intermental actions. At the same time, these interactions influence the thinking of the individual or the intramental actions. Moreover, the intramental actions of the teacher are influencing the thinking of the learners through the intermental actions. Hence, learning is achieved both through individual thinking and social thinking. This means that learning is both a cognitive and a social process.

Mediated actions which facilitate the learning process can be seen as ways that form linkages between the intermental and intramental planes. Extending Vygotsky's idea of the social situatedness of mediated actions, Wertsch (1991) pointed to mediated actions as linkages between the intramental and the intermental planes. The emphasis on the social situatedness of a mediated action means that the action is designed in accordance with the contextual situation. In helping student-teachers to teach science based on a constructivist view of learning, an example of a mediational means may involve the provision of a primary science teaching resource package for the beginning teachers. The resource package could include the unit plan showing the preconceptions that pupils may possess, the new concepts to be developed, and the activities to be conducted. Apart from the unit plan, there could be worksheets, suggestions for activities, and background reading materials for the beginning teachers. These materials would serve to help the novice contextualise what is learnt in the teacher education programme to their classroom situation. If the design and organisation of the materials are made based on the constructivist view of learning, the resource package would serve as a mediational means for the novices that socialize them into a culture of teaching science based on a constructivist view of learning as advocated by the teacher educator. Further, the teacher educator discussing with the novices the use of the package, could be taken as a mediated action. The task of the teacher educator is to interact intermentally with the novices about teaching science based on a constructivist view of learning, as well as to socialize the novices into the culture of primary teaching that values the constructivist views of learning.

From a sociocultural view of learning, Wertsch (1991) explained how mediational means facilitate learning. He proposed that the decontextualization of mediational means results in the mastery of abstract forms of knowledge. This notion of decontextualization treats knowledge as abstract objects free from the context or interactions between intermental or intramental action. However, in the thinking of the individual, these abstract images are further contextualized. This process of recontextualization or reinterpretation in the context of the individual gives rise to new meanings. It therefore means that in order to facilitate learners to make meanings out of an abstract concept, the teacher should consider ways that help the learners to contextualize and recontextualise the concept. In the teacher education programme, the design of teaching and learning is contextualized with the values and views of learning held by the teacher educator. The knowledge about teaching is then abstracted into basic principles about teaching and these principles are decontextualised. When the student-teacher starts to teach in a classroom, these principles are then recontextualised into the specific classroom situation and the needs of the pupils. Hence, learning to teach involves contextualisation, decontextualisation and recontextualisation among the student-teachers. The role of the teacher educator is then to facilitate this process to occur through mediated actions.

Language is an important mediational means and most mediation is achieved through this. Wertsch (1991) maintained that languages mould cultural and institutional forces, which in turn shape ideas and thinking in the individual's mind. Consistent with how the mediated actions enhance interactions between the inter- and intramental planes, language, as one mediational means, also effects the same linkage. Wertsch (1991) made this argument based on Bakhtin's view of social languages and speech genres, which are appropriated from the social settings through dialogic processes. Wertsch (1991) further describes the meaning of a social language, speech genre and the appropriation of a social language. A social language for Bakhtin is the language used that is specific to a stratum of society (for example, the teaching profession). A speech genre is described as a special form of speech that carries with it a meaning from the cultural setting and the individual's meaning. A speech genre is also a highly predictable framing device to understand the cultural meaning. For example, in the school, the beginning teachers can imply what other teachers may think about their teaching from their expressions as they pass by their classroom. Social languages are shared by other people or professions in society; the learner's task is to make it "one's own" and use it with his or her particular intention. The process of making the social language "one's own" is referred to as appropriation. The appropriation, or the dialogic processes, means that an interaction between the intramental and intermental planes must occur. When applied to science learning, this means the appropriation of the scientific language on the part of the pupils through their interactions with the teacher or with their peers. When applied to teacher education, it means the interactions between the novices, with the teacher educator, and with their peers that result in the appropriateness of the language for teaching science in the primary classrooms. As suggested by Wertsch (1991), the mastery of a particular language is essential in the process of socialization. In this sense, the novice teachers' appropriation of the language of teaching science can be regarded as the mastery of a language as they are being socialized into a community of science teaching.

Although this argument emphasizes social interactions, the mastery or the appropriation of language by an individual represents a change in the thinking or the mind of the individual. Speech genre, or the social language, is seen as a mediational means that facilitates the thinking process. Moreover, since the social language is acquired or appropriated through the socialization process, the individual's thought, which is expressed by the social language, is also significantly influenced by the social context. It therefore suggests that the thinking of a novice teacher as a learner is influenced by the social constructs in the school. Concluding from this, it can be seen that the thinking of the novice teacher is mediated by the speech genre used by other teachers in the school as well as what other teachers think about teaching.

Apart from language, the use of artifacts is one of the mediational means to facilitate learning. Pea (1993) argued that the use of artifacts could shape or advance the activity by providing the possible and necessary elements of the activity. The design of the artifact or the resource is largely dependent on the agent's intention, which may modify the activity of another individual. For example, the learning of the student-teachers may be mediated, influenced or shaped by the resources provided by the teacher educator. The teacher educator may encourage the student-teachers to teach science based on a constructivist view of learning by providing them with a number of references or readings on the development of children's science ideas, or resource books that provide worked examples of teaching science with an interactive approach. Further, the provision of examples of worksheets that encourage children to write down their own questions and video clips of science classes may also serve as resources for helping the student-teachers to construct their understanding about what teaching science is like based on a constructivist view of learning.

One way to bridge individual and social aspects of learning and thinking is that of Rogoff's (1995) suggestions to employ three planes of analysis to analyse human action. These planes are: apprenticeship, guided participation and participatory appropriation. These three planes were described as inseparable, and mutually constituting, but each could be the focus of analysis with the other two in the background of the analysis. The apprenticeship plane of analysis explains sociocultural activity from a community plane. Apart from focusing on expert-novice dyads, the apprenticeship plane of analysis considers constraining and supporting resources in the institutional structure that facilitates the activity. On a community plane, the resources available in the institution carry with them cultural values and meanings which may shape individual actions. This plane also emphasizes the interaction between peers in the process as they interact, and challenge each other in the process. Guided participation refers to the interpersonal plane of analysis. This emphasizes the interactions and communications between the participants in the activity, in which case the participants may or may not be known or visible to each other. The individual may follow the decisions made by other participants regardless of whether there is a contribution from the individual in making the decision. According to the notion of guided participation, the individuals may be influenced by the participants who are not known or who are invisible. These can be visualized as influences that are mediated through cultural artifacts like tools and signs, including language. For example, as pupils are influenced by thoughts of scientists, most of these scientists are not visible to the pupils. The third plane of analysis is participatory appropriation. This plane of analysis emphasizes the change in the participants during the process as they perform the activity. The roles of the participants are changing and the interactions between them are active. This plane of analysis is characterized by the dynamic nature of interactions, and how past experiences may inform and transform the activity. These three planes of analysis can be applied to explain the learning process of the novice teachers as their teaching actions interact with the school context. While all three planes of analysis emphasize the interactions between the individual and other participants in the system, the participatory appropriation plane of analysis assumes a more active role in the individual, and is different from the other two planes of analysis in the stress on the dynamics of the interactions and the changing roles of the participants. The three planes of analysis may serve as good lenses for studying the development of the novice teachers and offer potential explanation of how the student-teachers, beginning teachers learn as they interact with each other, with the teacher educator and with the school.

From a sociocultural view of learning, the student-teachers and the beginning teachers are seen to be learners whose learning is not only an individual process but is also influenced by the social surround. The sociocultural view of learning is therefore more appropriate for studying the learning of the novice teachers. The characteristics of the sociocultural view of learning which may be applied in explaining teacher education or teacher's learning include:

i. Social interactions are important in effecting the learning. Learning to teach can be seen as a socialization process into the teacher education and school context.

ii. The learning of the novice teacher may be facilitated with social mediation from the teacher educator, their peers or other teachers in the school who make up the social system.

iii. The participation in social interactions and providing support for learning is in itself a part of the learning process.

iv. The learning from the teacher education institute is contextualised by the teacher educator and the learning is then abstracted into basic principles or decontextualised and has to be recontextualised in the school or classroom context.

v. The learning of the novice teacher may also be facilitated by mediational means which includes cultural artifacts and language. The use of cultural artifacts includes reference books, samples of pupils' activities, sample worksheets, and activities conducted in the teacher education programme.

vi. Language is an important mediational means that shapes ideas and thinking in the novices' minds.

vii. The mediated actions and the cultural artifacts serve as linkages between the individual learner's (novice teacher's) mind and that of the teacher educator. They help interactions on the intermental and intramental planes.

viii. Learning to teach may be explained as an apprenticeship, guided participation and participatory appropriation which range from a community to an individual plane of analysis. The latter emphasizes the change in the participants as they perform the activity, their active role and their changing role as learners and transformers of the activity.

2.3 Science teaching

This section looks into studies of science learning and teaching that inform the present study in helping student-teachers to teach science. The first part of the section describes teaching science with a constructivist view of learning in terms of teacher classroom practices and looks into research which shows that such teaching does promote better learning. The second part compares teaching science with a constructivist view of learning with teaching science using other teaching approaches. The third part highlights the importance of interactions in helping pupils to learn science. For the present study, this part of the review identifies what is meant by better science teaching and makes clear the direction towards which the student-teachers need to develop their science teaching professionally.

2.3.1 Teaching Science based on a Constructivist View of Learning

Given the scenario of a "typical" primary science classroom in Hong Kong, wherein science teachers tend to rely heavily on the textbook and there is limited interaction between the teachers and the pupils, it is more appropriate to help the student-teachers to teach science based on a constructivist view of learning. This may help them to realize the importance of lesson preparation, group activity and interactions in the classroom. This section looks into research in the area of science education which explains what is meant by a constructivist view of learning, and describes the implications of this view of learning on the teaching of science. Research into children's ideas of science (Osborne and Gilbert, 1980) has found that children may hold different ideas about science, which can be different from the scientific view (Driver, 1981; Driver, Guesne and Tiberghien, 1985). Benson, Wittrock and Baur (1993) elicited pupils' conceptions of air by asking them to imagine a magic, magnifying glass looking into an empty flask. Their research indicated that pupils have different concepts of air, including a continuous model as distinct from a particulate model, and a top vacuum model against an evenly distributed model. The research findings also indicate that pupils find it difficult to visualise space between particles. In another study, BouJaoude (1991) revealed that children's conceptions of burning are based on everyday experiences. These views are fragmented, inconsistent, and not unified into a coherent set of understandings. These studies suggested that children's ideas about science can be different from the scientific view and future learning may be influenced by these ideas.

Having these ideas about science, children interpret new knowledge based on these ideas (Osborne and Freyberg, 1985) and may eventually form a view that is different from the teacher's or the scientific view. Northfield, Gunstone and Erickson (1996) quoted a summary of findings from research on students' science understanding over twenty years by White. The summary suggested that many students retain their own preconceptions about science which were formed outside the science classrooms even after they were taught the scientists' view. In addition, there may be a wide range of discrepancies between teacher and pupil perceptions in the science classroom, namely, the scientific context of the lesson/ activity, the scientific purpose of the lesson/ activity, the scientific design of the investigatory activity, doing the activity, getting results, thinking about what was done and what happened, the impact of the experience on children's views, and the relationship to predetermined outcomes (Tasker and Freyberg, 1985). The research on children's ideas about science has led to the development of a constructivist view of learning in science. These discrepancies between the children's science, their interpretation of the classroom activities and the teacher's view were explained by the situation that children interpret their new knowledge or experiences based on their previous concepts (Osborne and Freyberg, 1985). Therefore, in order to help the children to learn, the teacher has to acknowledge the existence of the children's ideas. Moreover, based on a personal constructivist view of learning, children are involved in the learning process by making linkages between the new and old ideas (Osborne and Wittrock, 1985), or are assimilating new information into the existing mental structure or are accommodating the new knowledge in a modified form (Piaget, 1970).

The constructivist view of learning has a number of implications for science teaching. Science teachers need to focus on the learning of the pupils instead of their own teaching by:

- acknowledging pupils' preconceptions;
- helping pupils to undergo conceptual change;
- helping pupils to take a greater responsibility for their learning;
- helping pupils to make connections in their learning;
- helping pupils to apply what they have learnt.

First of all, science teachers need to acknowledge the ideas that children hold about science which are often described as "alternative conceptions", "misconceptions" and "preconceptions". The use of these terms implies different assumptions about the learning and teaching of science. The term "alternative conceptions" is used to describe the ideas that pupils have and may use to explain how things behave as they do (Bell, 1993a). The term "preconception" has a similar meaning and assumption about learning. However, the term "preconception" stresses that the idea is held before the science lesson has occurred, while "alternative conception" may still be held after the lesson as the pupils reject the new ideas. The term "misconceptions" emphasizes the fact that the ideas that pupils have are different from scientists' ideas and that they are wrong. The science teacher's role is to correct the misconceptions to achieve scientists' conceptions (Ebenezer and Connor, 1998). These "misconceptions" may be held before or after the science lessons, but have to be modified by the "correct" scientific ideas after the science lessons.

Although there are different terms for describing children's ideas about science, each of which imply different assumptions about teaching, identifying and acknowledging children's ideas is important in the teaching of science. Based on a constructivist view of learning, the teachers' role is to start with the "preconceptions" and help the learners negotiate their own understanding towards the science concepts (Ebenezer and Connor, 1998). The importance of acknowledging children's ideas and then helping students to understand the science concepts were highlighted by Stavy (1990) and Cosgrove and Osborne (1985). Stavy (1990) suggested using the students' ideas as a starting point for teaching and promoted the use of analogies in changing their ideas. In helping students to modify their alternative science conceptions, Cosgrove and Osborne (1985) proposed a "Generative Learning Model of Teaching". The emphasis of the model is on the preliminary phase in which the teacher needs to understand the children's view, and in other phases to make the science view intelligible and plausible by their teaching activities such as demonstration or experimentation.

Secondly, based on a constructivist view of learning, science teachers need to address the fact that pupils come to science class with previous conceptions, and help them to undergo conceptual change. As Ausubel (1968) states, "The most important single factor in influencing learning is what the learner already knows; ascertain this and teach him accordingly." More recently, Appleton (1997) suggests that teachers should constantly compare pupils' ideas with scientists' ideas and find the fitness of match during the learning process. Similarly, Demastes, Good and Peebles (1996), in studying patterns of conceptual change in evolution, found that pupils' change in concepts does not always occur as "wholesale" change, meaning that their ideas do not revert to scientists' ideas completely and instantaneously after the lesson, but instead, a cascade or gradual change occurs. The teacher should hence realise in the first place the conceptions that children hold at the beginning, and realise the changes as the teaching progresses.

Thirdly, teachers need to encourage pupils to take a greater responsibility for their learning and think actively in the science lessons. An attempt with an aim to improve the quality of teaching and learning, though not specifically on science teaching, is made by Baird and Northfield (1987) in the PEEL project. Consistent with a constructivist view of learning, students are encouraged to think about their learning and bring up questions on the topic, organising them into lists, and determining their interrelations.

Fourthly, teachers need to help pupils to make connections and apply what they have learnt. Brown (1992) suggested that teachers should use examples in teaching physics. The connection of the examples to previous concepts is important in order for pupils to easily make sense of their learning. From these findings, the implications for teaching based on a constructivist view of learning included recommending that teachers start with evidence and begin with examples that maximize perceptual reinforcement for correct intuitive knowledge and common typical examples. Moreover, teachers were also encouraged to set the boundaries in helping the students to apply the knowledge and channel the knowledge to relevant problems. In addition, the importance of helping to develop their existing ideas and applying them in new situations is stressed by Brown and Clement (1989). Recognizing the appropriateness and the applicability of models in different situations are also seen to be important learning outcomes (Stavy and Berkovitz, 1980).

To summarize the implications of the constructivist view of learning on science teaching, the present study focused on teaching science as taking into account pupils' thinking, which was illustrated by Bell and Gilbert (1996) as:

- finding out the ideas, opinions, interests, concerns, and experiences that students bring to a lesson;
- encouraging the students to think about their own prior ideas and (new)

scientific ideas;

- finding out what meanings the students are constructing during the lesson;
- presenting and explaining the scientific ideas using a variety of resources (including the teacher);
- responding to, and interacting with, the students' thinking;
- helping students ask questions, find answers to their questions, and investigate and test out their own ideas;
- initially teaching science in contexts that are familiar to and of interest to students;
- helping the students to reflect on their own learning, in terms of both the degree of understanding of the content, and ways of thinking and learning; and
- assessing the change and growth in students' ideas, as well as the extent to which they have learnt the scientific ideas. (Bell and Gilbert, 1996, pp. 10-11)

Although the constructivist view of learning does not dictate a certain teaching approach, it does suggest certain teacher actions that are helpful in facilitating pupils' learning. A list of nine teacher actions that may help pupils in their conceptual change was developed for the present study:

- Presenting questions for pupils
- Inviting pupils to ask questions
- Asking pupils to predict results of practical activities
- Illustrating by using a range of examples
- Illustrating by using practical activities
- Relating new ideas with previous concepts
- Using the newly learnt ideas in new situations
- Pupil initiated activity
- Clarifying pupils' ideas by using other examples

The development of this list is based on a teacher development project that promoted science teaching based on a constructivist view of learning (Bell, 1993b). This list was relevant for the present study in carrying out the lesson observations during the teaching practice period and beginning teaching phase. However, these are teacher actions that are not common in "typical" science lessons in the Hong Kong primary school context. Based on a constructivist view of learning, the teacher needs to acknowledge pupils' preconceptions and hence has to find out what the pupils' ideas are as they teach. Therefore, they have to be asking pupils questions and finding out pupils' ideas before, during and after their teaching. Secondly, the teachers need to promote their pupils to think and to raise questions. This is seen as a difficult task for the teachers if they are teaching with a tight teaching schedule and have limited science background themselves. Thirdly, in order to promote pupils' thinking and to find out their preconceptions, the teacher needs to ask the pupils to predict the results of the practical activities. Fourthly, the teacher may help the pupils to develop their ideas and concepts through illustrations. In order to illustrate the concept, the teacher may employ a range of examples or demonstrate practical activities. In the Hong Kong context, as there is limited resource and space in the classroom, teacher demonstrations are more frequent than pupils working on group investigations. Fifthly, the teacher needs not teach according to the textbook and take each topic as separated lessons. The teacher when teaching based on a constructivist view of learning, needs to relate previous concepts covered in their lessons with the new ideas. The last two teacher actions on the list are expected to be more applicable at the end of a topic or lesson. The teacher may provide an opportunity for the pupils to use the new ideas learnt and connect their ideas by solving a problem or case at the end of the lesson. The teacher may conclude the topic and ask the pupils if they have questions, or initiate a different investigation. If they find that pupils still hold alternative ideas, the teacher may also attempt to clarify pupils' ideas by using other examples, which may not be planned or covered in the textbook. This may be difficult for the student-teachers due to their limited science background and for other teachers as they tend to rely heavily on the textbook.

It is important that the above teacher actions may lead to better learning among the learners. In fact, teachers who participated in a "Learning in Science (Teacher development)" project (Bell and Gilbert, 1996) suggested that teaching science based on a constructivist view of learning may lead to the development of better learning conditions and better learning outcome among their students. Better learning conditions referred to more enjoyment of science, increased social cooperation, gaining better confidence, improving motivation, increased ownership and responsibility for learning. These conditions arise as a result of learners' participation in the learning activities, and involvement in researching their own interests and interactions in the classes. Moreover, the teachers also identified better learning outcomes among their students. Students had developed better learning skills, which included asking questions, discussion skills and metacognition. Conceptual development, being able to transfer and use new ideas, increased retention of new ideas, and better achievement in examinations were also suggested by the teachers as evidence of better learning.

2.3.2 Comparing teaching science based on a constructivist view of learning with other science teaching approaches

While the constructivist view of learning emphasizes the linkage between old or previous concepts and the ones newly learnt, there are other teaching approaches in science education that are based on different assumptions. This section compares teaching science based on a constructivist view of learning with other science teaching approaches. To summarize, a comparison of the various approaches in teaching science is constructed based on Fleer and Hardy (1996) and Barker (1991), and is represented in Table 2a. Teaching science based on a constructivist view of learning emphasizes the active involvement of the learner in the construction of the linkage between the new knowledge with previous understandings. The teacher has to stimulate the learners to think, and monitor the changes in the concepts. The process skills approach assumes a view that learning is effected by observing, classifying, measuring, hypothesizing, predicting, communicating and experimenting. The learners are involved in the process of devising experiments and observation while the scientific laws are "out there" to be discovered. The teacher's role is to provide practical activities that help the learners to develop the process skills. The discovery approach aims to help learners to find out the scientific concepts which exist "out there" through practical activities. The teacher is the designer of the required activity such that the necessary "discovery" may occur. In the transmission approach, the learner is assumed to learn by listening to the teacher and to attempt to understand or memorize what was heard. This is a teacher-centered approach which requires the teacher to select and modify science language for the explanation.

Harlen (1998) compared rote learning with learning for understanding, the latter being based on a constructivist view of learning. The difference between rote learning and the constructivist view of learning is mainly based on having learners capable of forming the linkage between ideas in the latter. This linkage allows further transformation and applications in other contexts, which allows the learner to make predictions and explanations. This application is not possible if there is only rote learning, when verbal information is remembered, as encouraged in the transmission teaching approach. The transmission approach does not consider pupils' experiences or preconceptions or how these ideas relate to their conceptual development in the process of learning (Ebenezer and Connor, 1998).

Table 2a A comparison between various approaches in science teaching

	Teaching science based on a constructivist view of learning	**Process Skills Approach**	**Discovery Approach**	**Transmission Approach**
Views of Learning underpinning the approach	♦ Constructivist view of learning.	♦ Learning by experiencing, observing and experimenting.	♦ Learning by discovery or finding out.	♦ Learning by listening to the teacher.
Learning	♦ Learners actively construct science learning in relation to previous understandings.	♦ Learners observe, devise experiments and discover scientific laws or truths. These help to understand and predict.	♦ Learners try to find out the scientific principles through hands-on experiences or by interacting with the given resources.	♦ Learners listen, try to understand then memorize.
Teaching	♦ Stimulating learners to think, discuss and monitor changes in conceptions. ♦ Encourage pupils to ask questions, be active in their learning, help pupils to test out ideas and apply what they have learnt.	♦ Provide opportunities for hands-on activities and guide learners to develop specific skills e.g. designing investigations and communicating findings.	♦ Teacher provides the resources and arranges the experience for a "discovery" of science concepts to occur.	♦ Direct instruction or exposition, teacher-centred approaches. ♦ Select and modify science language to explain science knowledge and to ensure learners' understanding.

Teaching based on a constructivist view of learning differs from a guided discovery approach. In the constructivist view of learning, learners are not empty vessels to be filled, nor is knowledge "out there" to be obtained. Learners have preconceptions in their minds and that knowledge is constructed in the minds of the individuals. The constructivist view of learning supports the notion of learners having preconceptions. Harlen (1998) stated that "ideas emerging from each learning experience are derived from those held at the start of the learning experience". Pupils may then have their own design based on their preconceptions, and investigate the problem or find out the answer to their own questions (Ebenezer and Connor, 1998). This contrasts strongly with the guided discovery approach, which assumes that the learner has no prior idea of what is to be learnt, and science knowledge has to be discovered in the physical world. In a guided discovery approach, the teacher then arranges a sequence of investigations and helps the pupils to discover the answer. In the present study, the student-teachers had had much experience of learning and teaching based on the guided discovery approach in their past education experience as well as through other curriculum studies modules in General Studies. They may at times confuse the constructivist view of learning with that of the guided discovery approach. The main point of difference that the student-teachers need to note between the two is on the view about whether the learner possesses preconceptions and whether science knowledge is constructed in individual's minds or is "out there" to be discovered.

Teaching based on a constructivist view of learning differs from a process skills teaching approach. Process skills include a number of skills such as observation, recording, making hypotheses and analysing. The place of process skills in science learning should be addressed, as these are helpful in facilitating pupils to develop their concepts. There has been a shift from the processes approach which was advocated in the 1960s in science education (Harlen, 1998). The emphasis on processes in the 1960s was associated with a relative neglect of content and development of science concepts. This suggests that process skills should not be taught independent of the science content (Millar and Driver, 1987). Moreover, when the constructivist view of learning is considered, the learning of process skills is based on its role in the development of understanding, and, in other words, conceptual development. These skills help the pupils to test out their ideas, to form linkages with old concepts, and to apply what they have learnt. In this way, the learning of process skills should, therefore, be related to the development of new concepts.

Drawing on the research findings on how pupils may undergo conceptual changes and learn new concepts (Demastes, Good and Peebles, 1996; Brown, 1992) as well as the better learning conditions and outcomes (Bell and Gilbert, 1996; Bell and Pearson 1992) generated from science teaching based on a constructivist view of learning, it is therefore recommended to introduce the constructivist view of science learning to the student-teachers so that they can aim for pupils' understanding, thinking and active involvement in the lessons. While keeping in mind the basic idea of a constructivist view of learning, to aim for pupils' understanding, and to engage them in thinking, the student-teachers may choose to employ the various strategies of science teaching in different lessons. The teaching activities as advocated in a guided discovery approach can be implemented when the teachers aim to get pupils to explore new ideas. While the strategies in a process approach described above can help the pupils to test out their ideas, the process skills learnt can also be applied when the pupils are doing their inquiry on specific concepts. The teacher may adopt the strategies in a transmission approach in an attempt to explain to the pupils about a certain concept after an inquiry or exploratory activity. As the student-teachers in the present study are introduced to a constructivist view of learning, having this view of learning in mind, the implementation of the various strategies at different times of their teaching carry the purpose of helping the pupils with their concept development.

2.3.3 The importance of interactions in the classroom

A central aspect of teaching based on a constructivist view of learning is that of ensuring interactions between the teacher and students, and between students. Therefore, teaching with a constructivist view of learning does not only include applying the activities or finding out pupils' preconceptions, but also stresses the importance of interactions between the teacher and the pupils. Based on a constructivist view of learning, these interactions may help the teachers to assess pupils' preconceptions and their change in conceptions during the teaching process, and to stimulate them to reflect on their own learning. Discussions, convincing each other and explaining a situation to others are seen as important aspects of a dialogue-based strategy in science teaching (Champagne, Gunstone and Klopfer, 1985). Scott (1999) described how pupils treat the utterances of others and of themselves as thinking devices. He explained that pupils take an active stance toward the information in the classroom by questioning and extending it. Through this process the pupils incorporate the ideas into their thinking. Moreover, the importance of social interactions is also supported by the social constructivist and the sociocultural views of learning.

Based on a social constructivist view of science learning, Driver, Asoko, Leach, Mortimer and Scott (1994) emphasized the dialogic process in science. Science learning is seen as enculturation, and the role of the teacher is to mediate learning through the use of cultural tools. Teaching also involves understanding pupils' thinking through the interactions and diagnoses of their needs. The discursive or dialogic process is one that socializes pupils into the practices and knowledge of the scientific culture. The significance of teacher-student and student-student interactions is regarded as being ways that help the students to articulate their thinking as they learn science.

The sociocultural view of learning emphasizes the role of social interactions in the learning process. Congruent with Vygotsky's perspective, pupils need to engage in discourse if meaningful learning is to occur. The definition of reflective discourse was offered by Van Zee and Minstrell (1997) (pp.209) as: (i) students express their own thoughts, comments and questions, (ii) the teacher and individual students engage in an extended series of questioning exchanges that help students better articulate their beliefs and concepts, (iii) student/student exchanges involve one student trying to understand the thinking of another. This definition suggests the importance of the interactions between the teacher and the student as well as those between the students themselves. The interactions facilitate the learning and are also an integral part of the learning.

Taking the three views of learning together, the importance of interactions is highlighted and relevant to science teaching. The interactions being a part of the learning process, can facilitate the change in concepts, socialize the pupils into the scientific culture and support the learning while forming a part of the learning.

This section has defined what is meant by a constructivist view of learning in science, and has drawn on research findings to find out the implications of this view for teaching. The implications include engaging pupils in thinking and the use of other approaches when necessary to support conceptual development. While science knowledge is seen as actively constructed by the pupils, it is also discursive in nature. On that account, besides considering pupils' preconceptions, and helping them to establish a linkage between new and old ideas, teachers also need to engage pupils in discussions, question them, and encourage them to raise questions. Having summarized the implications of the constructivist view of learning in science teaching, the next part looks into the knowledge of the teacher and the ways of helping novice teachers to teach science with this view in mind in teacher education programmes.

2.4 Teacher education for science teachers

The constructivist view of learning has informed teachers about pupils' learning in the classroom, and hence suggested implications for science teaching. The concern of the teacher educators is then to prepare student-teachers to teach science with a constructivist view of learning in mind. This section describes firstly how teacher knowledge is defined, and secondly, provides a framework to study the teaching of the student-teachers and the beginning teachers. Lastly, it outlines teacher education strategies that help to achieve this aim.

2.4.1 Defining teacher's knowledge

In defining teacher knowledge, the present study draws on what Shulman (1987) calls teacher's knowledge base. He has identified seven knowledge bases upon which teachers draw during their teaching. These are:

- Content knowledge;
- General pedagogical knowledge, with special reference to those broad

principles and strategies of classroom management and organization that appear to transcend subject matter;

- Curriculum knowledge, with particular grasp of the materials and programmes that serve as "tools of the trade" for teachers;
- Pedagogical content knowledge: that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding;
- Knowledge of learners and their characteristics;
- Knowledge of educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; and
- Knowledge of educational ends, purposes and values, and their philosophical and historical grounds. (Shulman, 1987, p.8)

Among the seven forms of knowledge, the Pedagogical Content Knowledge (PCK) helps to define the knowledge that the student-teachers need to learn in teacher education and a way to study teaching. The significance of Pedagogical Content Knowledge is apparent in Shulman's (1987) description of teaching as a cyclical process. The cycle starts and finishes with comprehension when the teacher thinks and re-thinks about the subject matter structures and ideas related to the discipline. The teacher starts by comprehending the material to be taught, that is, drawing on the content knowledge. This is the teacher's understanding of the substantive structure of the subject, the basic concepts, and the ways in which they are related. This is then adapted to suit the students' needs and is represented in other ways when it is taught. The transformation draws on the teacher's Pedagogical Content Knowledge, that is the form in which content knowledge is effectively taught, and includes examples and illustrations that aid explanation. This also involves the selection of materials for use, the presentation of key ideas, and the selection of an appropriate teaching method. The actual teaching is referred to as instruction. This is followed by an evaluation of the effectiveness of the teaching on students' learning. The teacher reflects on the action of teaching and the process is started again. Building on this cyclic conception of teaching, research into teaching needs to include the various stages in the process from the comprehension, transformation, instruction and evaluation to the reflection on teaching effectiveness.

This cycle has implications for how teachers are educated and how teaching can be studied. Moreover, it has many characteristics of a good model that provides an analytical framework for studying teacher cognition while providing an integrated picture of teacher knowledge and classroom practice (Gess-Newsome, 1999). According to Shulman (1987, p.8), Pedagogical Content Knowledge is "the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of the learners, and presented for instruction". The representations and alternative ways of explanation form part of the Pedagogical Content Knowledge as "analogies, illustrations, examples, explanations and demonstrations" (Shulman, 1987, p.9). This blending or integration of content and pedagogical knowledge suggests that teacher education programmes need to integrate the learning of the content knowledge and the pedagogy. This view is supported by Lederman and Gess-Newsome (1999) who found that student-teachers were heavily influenced by the quality of the teacher education programme, in terms of whether they were able to integrate the subject knowledge and the pedagogical structures learnt. Under Pedagogical Content Knowledge, the various parts of the process appear in a cyclic form suggesting that the knowledge is changing with time. This means that what is learnt in the teacher education programme, including the content knowledge and the teaching method, are not static forms of knowledge but have to be adapted in the classroom context and continuously adjusted. This is also consistent with a sociocultural view of learning that knowledge is contextualized. In terms of researching teaching, this involves the study of the preparation, the selection of content and teaching method, the actual instruction, and how teachers view or reflect on their own performance.

The above cyclical process provides an overall picture about teacher preparation and the research into teaching. The following discussion looks into how the literature informs the practice of teacher education, and the attempts of teacher educators in preparing science teachers to teach with a constructivist view of learning in mind.

2.4.2 Preparing teachers to teach with a constructivist view of learning

The intervention of the present study is informed by the literature about strategies that may facilitate the development of student-teachers. The following are the strategies that have been suggested in the literature to facilitate the development of the student-teachers to teach in a way that is based on a constructivist view of learning. They include:

i. Acknowledging the importance of the past experience of the student-teachers
ii. Teacher educators should "practice what they preach"
iii. Encouraging student-teachers to reflect
iv. Developing student-teachers' confidence and self-efficacy in science teaching
v. Developing a pedagogical repertoire
vi. Influences of the school context
vii. The need for on-going support

These strategies aim to generate changes in the teaching of the student-teachers such that they may teach science based on a constructivist view of learning. However, changes in teaching actions may occur when there are changes in views of learning and teaching, accompanied by gains in confidence in teaching science. These strategies therefore aim to generate changes in the student-teachers' views of learning and teaching, confidence in teaching science, and classroom practice.

(i) Acknowledging the importance of the past experience of the student-teachers

From a sociocultural view of learning, the previous learning experience of the student-teachers may be interpreted as originating from a cultural background which may not be consistent with the culture in the teacher education programme. Studies of teacher education have also indicated the importance of past experience in the process of learning to teach. The personal conceptions of student-teachers that are held as they come to teacher education courses, can exert a powerful influence on what they learn and accept as valid knowledge (Kagan, 1992; Mahlios and Maxson, 1995). Moreover, student-teachers differ in how they conceptualise the process and have expectations for their own learning, which in turn influences how they attempt to structure and make sense of their training experiences (Calderhead, 1991). Similarly, in in-service teacher development, how teachers interpret and receive new ideas and practices is suggested to be influenced by their previous ideas about teaching and learning (Bell, 1993b). While research on student-teacher's learning (Bennett and Carre, 1993; Halliday, 1996) suggested that student-teachers hold ideas about teaching and their roles as future teachers as they join the teacher education programmes, the design and content of teacher education programmes rarely relate to student-teachers' beliefs and conceptions. This gap in the teacher education programmes contributes to a failure to achieve meaningful learning and reflective inquiry (Gunstone and Northfield, 1992; Tobin, 1992). Feiman-Nemser (1989) recommended that teacher educators be aware of the incoming beliefs and attitudes or the preconceptions of the student-teachers in order to promote conceptual changes in pedagogical thinking.

In line with this call for considering preconceptions in teacher learning, Loughran (1997) maintained that student-teachers need to be challenged through pedagogy and be stimulated to consider and reconsider their existing knowledge in light of the new experiences. In this way, existing views of science teaching can be reconsidered as the student-teachers gain new science learning experiences. On the same line of argument, von Wright (1997) suggested that the student-teachers' world view influences how new learning experiences gained in teacher education are organised. Moreover, their views change as there are new social interactions, suggesting that the learning experiences are re-interpreted. This notion that teachers construct and reconstruct the meaning of what it means to be a teacher, and develop evolving conceptions of teaching is also supported by Sutton, Cafarelli, Lund, Schudrell and Bichsel (1996).

Therefore a part of teacher education is teacher educators eliciting student-teachers' preconceptions about science teaching, changing their views about teaching and learning, and facilitating changes in their practice in the classrooms. In changing teachers' beliefs and practices, Louden and Wallace (1994) related that teachers change in successively small steps as they are exposed to new ideas and try alternative ways of teaching. Carey (1985) shared this view that changes in teaching beliefs and practices are incremental. These studies suggest that teacher educators have to start from the student-teachers' previous views about science teaching and learning, and work to change these ideas to consider the implications of the constructivist view of learning for the classroom practice.

(ii) Teacher educators need to "practice what they preach"

The second strategy for helping student-teachers to teach science based on a constructivist view of learning involves the teacher educators putting into practice what they preach. A number of studies have been conducted to inform how science method courses in teacher education programmes may be conducted to promote teaching based on a constructivist view of learning (Abd-El-Khalick and BouJaoude, 1997; Stofflett and Stoddart, 1994; Munby and Russell, 1997; McDevett, Heikkinen, Alcorn, Ambrosio and Gardner, 1993). Findings from these studies suggest that as student-teachers are asked to teach with a constructivist view of learning, teacher educators should assume the same approach. Abd-El-Khalick and BouJaoude (1997) urged teacher educators to regard student-teachers as active learners, and challenge their beliefs about teaching and learning in the teacher education programme. Moreover, student-teachers must learn science concepts or science teaching with a constructivist view of learning before they are able to teach using the same approach (Stofflett and Stoddart, 1994). However, there can be a discrepancy between the approach adopted in the teacher education programme, and the approach for teaching young children that the programme advocates (Munby and Russell, 1997). Therefore, in order to convince student-teachers to teach with a constructivist view of learning, teacher educators should "practice what they preach". Consistent with this argument, McDevett, Heikkinen, Alcorn, Ambrosio and Gardner (1993) suggested that either science content or science method courses in teacher education programmes should build upon student-teachers' experiences, and emphasize science concept development and changing alternative concepts. By "practising what they preach", the teacher educator is modelling the teaching approach that is advocated to the student-teachers. The relationship between modelling and learning to teach science is illustrated by Russell (1997) and Loughran (1997). The process includes the communication of the approach by the teacher educator, and reflection among the student-teachers. The message of how to teach in classrooms is communicated through how the teacher educator teaches, and the student-teachers learn how to teach from their own learning experience (Russell,1997). By being engaged in the learning process themselves, the student-teachers have an authentic experience of seeing and feeling the diversity of outcomes for themselves through learning from a particular approach.

In order to affect educational reforms, Liston and Zeichner (1991) summarized the features that teacher education programmes should possess. The content and the pedagogy of the programme must provide a condition or environment that nurtures the development of the student-teachers in the desirable direction. They further explained that this means a consistency and coherence between the content and the pedagogy, in that teaching is modelled by the teacher educators. They provided examples of teacher educators working with cooperative learning structures themselves as they are advocating the same approach for the student-teachers. In order to maintain coherence, to model or to regard student-teachers as active learners, the science methods course has to be based on a constructivist view of learning in its delivery, as the same notion is advocated in the module.

(iii) Encouraging student-teachers to reflect

The third strategy to prepare student-teachers to teach with a constructivist view of learning is to encourage student-teachers to engage in discussion, and stimulate their reflection. While the social constructivist view of learning regards science as discursive in nature, and considers that learning science involves interacting with the teacher and with the peers, learning about teaching can also be conceptualised in the same way. Loughran (1997) suggested that student-teachers reflect upon their cognitive and affective development after the teaching episodes in the teacher education programme. The student-teachers reflect on the pedagogy employed by the teacher educator, on how and why it was used as well as developed. The student-teachers then make their own decisions about how to adopt the approaches in their own practice. This process of reflecting on the learning experience was referred to as a "debriefing" by Meyer-Smith and Mitchell (1997). The debriefing included four dimensions: what science content was learnt, what was learnt about teaching, what was learnt about learning, and what was the impact (if any) on their personal beliefs about teaching and learning. Hoban (1997) suggested that the student-teachers analyse their own learning, identify enhancing and inhibiting factors, and hence distinguish the impact on their science teaching. Consistent with a constructivist view of learning, the above process involves learning to teach through experiencing learning, and hence leads to a construction of a personal pedagogy. The challenge for the teacher educator is thus to determine and bring into practice enjoyable learning experiences or effective teaching activities that are intended to be modelled, such that it becomes more likely that student-teachers will desire to include similar practices in their own science teaching. Moreover, reflection has to be promoted among the student-teachers such that they can build up their personal pedagogy.

In the process of constructing the personal pedagogy among the student-teachers, the sharing of experiences and discussions can promote their reflection. Pedersen and McCurdy (1992) concluded that learning to teach involves not only diverse experiences in teaching, but also focussed discussions of the experiences. Chin (1997) described the role of the teacher educator in a science methods course as helping student-teachers to articulate, critique and practice their own perspectives on teaching. Learning to teach was also found to have best occurred through shared experiences and critical discussions. Through this sharing and discussion among the student-teachers, the awareness of the goals and the views of teaching and learning became explicit. Moreover, Sutton et.al. (1996) identified that student-teachers found a variety of peers helped in changing their thinking as well as stimulating their thinking. This finding points to the importance of having opportunities for student-teachers to discuss and interact with each other.

This highlights the importance of the interactions between the student-teachers and the teacher educator as well as the provision of opportunities for the student-teachers to discuss their experiences and ideas about teaching. The teacher education programme module therefore needs to offer a supportive environment for the student-teachers to talk about, reflect, analyse and critique their ideas about science teaching.

(iv) Developing student-teachers' confidence and self-efficacy in science teaching

The fourth strategy for the teacher educator to help student-teachers to teach science based on a constructivist view of learning is to develop student-teachers' confidence and self-efficacy in science teaching. There are also studies that stress the development of teachers' attitudes and confidence in science teaching. Westerback and Long (1990) found that increased content knowledge could reduce experienced elementary teachers' anxiety about science teaching. They also reflected that teachers who are more comfortable with science are more likely to devote more time to teaching it, and are more likely to teach it with creativity. The notion of self-efficacy in science teaching is related to the attitudes and confidence in science teaching. Self-efficacy refers to the teacher's confidence and belief in being able to teach science and effecting learning outcomes among their pupils. The relationship between science teaching efficacy beliefs and preparing student-teachers to teach science is supported by a number of studies. Ramey-Gassert and Schroyer (1992) summarized related studies, linking quantitative findings with qualitative ones, and suggested that elementary teachers' poor self-efficacy has resulted in a science anxiety, poor attitudes towards science, and an unwillingness to spend time teaching science. Based on this notion, one of the aims for science teacher education courses should be to improve student-teachers' science teaching self-efficacy. Schamann and Orth Hampton (1995) believed that science teacher educators need to be aware of the implications, and organise method courses that improve student-teachers' science teaching self-efficacy. Moreover, Ramey-Gassert and Schroyer (1992) suggested that purposeful selection of science experiences can improve science teaching self-efficacy and result in better attitudes towards science.

(v) Developing a pedagogical repertoire

The fifth strategy for helping student-teachers to teach science with a constructivist view of learning is to develop a pedagogical repertoire among the student-teachers. The constructivist view of learning implies a number of practices about science teaching in the classroom, such as finding out pupils' preconceptions, helping them to change their concepts, offering opportunities to test out and apply their ideas. Abd-El-Khalick and BouJaoude (1997) suggested that the programme needs to provide opportunities for the student-teachers to familiarize themselves with children's alternative conceptions, and realize how these may influence their learning. Teaching science based on a constructivist view of learning is a perspective on teaching, not a detailed approach. For example, the teacher needs to know about the students' preconceptions before the teaching is conducted. These preconceptions could be elicited using a number of activities such as brainstorming, interview-about-instances and concept maps (Bell, 1993a). Student-teachers as future science teachers need to know about the science preconceptions held by their pupils. Science teacher educators (Peterman,1991; Russell, Harlen and Watt, 1989) have worked with teachers to familiarize them with the research on children's preconceptions, and to help them to teach based on a constructivist view of learning in their science classrooms. In this way, the novice teachers can then design strategies that target the changes in the concepts among the children. Borko and Putnam (1996) reviewed those studies that have identified that the limitations in student-teachers' repertoires of teaching strategies are associated with problems in teaching for understanding. Hence, it was suggested that in helping student-teachers learn to teach, teacher educators have to support them to develop a repertoire of instructional strategies and representations. Moreover, Alexander (1995) indicated that a pedagogical repertoire is necessary for the prospective teachers in adapting to the unique practice needs and circumstances of an individual teacher's professional situation. This range of pedagogical strategies (which includes a range of materials, content and teaching styles) can be used at different times (Gipps, 1995) or in different contexts according to pupils of different behaviour and readiness to be active in learning, and grouping pupils by their ability levels (Gipps, McCallum and Brown, 1999). Moreover, the teaching style is also likely to be governed by the prevailing philosophy of the school. Based on these studies, a repertoire of teaching strategies is essential in order to equip the student-teachers to meet the various needs of the pupils and the school in the future. Further, the above studies also point to the significance of the contextual influences on teaching in the classroom.

While a range of teaching approaches is introduced, McDiarmid, Ball, and Anderson (1989) pointed out that teacher educators have to be aware of how the different approaches convey messages to pupils about the nature and content of science, and the ways questions are taken or problems are solved. A comparison of the various approaches in teaching science was made based on Fleer and Hardy (1996) and Barker (1991), and was represented in Table 2a (Section 2.3.2).

Although there are differences in terms of the views of learning, the teaching, and the nature of science among the various approaches, Fleer and Hardy (1996) maintained that teaching science based on a constructivist view of learning incorporates the positive aspects of the other four approaches. While the teacher has a constructivist view of learning in mind, he or she may choose to implement various strategies at different times of the teaching. For example, scientific investigations or the use of process skills may help to give pupils a glimpse of how a scientist works. The unstructured discovery activities may be adopted in the early phase of a lesson to help pupils to explore widely on the topic, or for a structured investigation, as the pupils have decided on a question to explore. The transmission strategy may be used as the teacher chooses to introduce the scientists' views after the pupils have expressed their views. However, while adopting the various strategies, the teacher is encouraged to emphasize engaging pupils with thinking, developing their own understandings, and exploring using their own questions, and the teacher has to be sensitive to the pupils' ideas as these change or develop in the course of study. Although the student-teachers are introduced to a repertoire of teaching strategies and are encouraged to teach science based on a constructivist view of learning, a number of factors may influence their decision as they develop or construct their personal approach. These influences include their prior experiences of learning science, and the school or classroom context.

(vi) Influences of the school context

The sixth strategy that helps student-teachers to teach science based on a constructivist view of learning is for teacher educators to consider the influences of the school context. Based on a socio-cultural view of learning, the social context both structures and influences the learning of an individual. Although there are studies informing the structure and composition of science teacher education courses, what is learnt in the programme is influenced by the contextual situation. Research studies have identified the influences acting on the learning process of the student-teachers. In a study of the influence of teacher education programmes on student-teachers teaching science and technology, Skamp (1995) found that different sources of influence operate in various phases of the programme. At the initial stage or on entry into the teacher education programme, the student-teachers' previous experiences as a science and technology learner set a basis for further learning. Later in the programme they are affected by the taught unit on science and technology. During the teaching practice, they are more influenced by the supervising teachers and their classroom experience. The school-based influence was found to be mostly negative.

The field experience provides an opportunity for student-teachers to select or adapt the pedagogical approaches learnt in the programme for their own teaching (Calderhead, 1988). This selection or adaptation is mainly determined by the student-teacher's personal view of teaching. Koehler (1983) regarded teaching practice as an important element of any teacher education programme, and that it imposes the strongest influence on learning to teach. This is a time when student-teachers contextualize their learning in the programme. Moreover, it is difficult to relate theory and practice if there is no reference to the school context or any form of teaching experience. These experiences in the teaching practice influence how the student-teachers interpret what is learnt in the teacher education programme (Calderhead, 1988).

Apart from the dilemmas and influences that are specific to science teachers, studies about student-teacher experiences in teaching practice in general, can help to inform the present study about science teacher learning. Field experience or the student teaching experience may provide a reference for the individual about how he or she is going to teach in the beginning teaching stage. Student teaching has been documented to involve emotional and professional changes in the student-teachers. In an extensive study by Harrington and Sacks (1984), six aspects of the development of student-teachers during their teaching practice were identified. In the study, the student-teachers were invited to be videotaped, to fill out a role transition questionnaire and to write an ongoing log over a fourteen-week semester. The data collection was structured to capture the student-teachers' thoughts, feelings, their major concerns and how they have been preparing for their new role. The data were collected prior to and during the teaching practice. Harrington and Sacks (1984) suggested that before students begin to work in the classroom, stage one (anticipation) starts. This stage is characterized by eagerness, excitement and great anxiety. In stage two (entry), student-teachers are excited about beginning the experience, but worry that the challenge is too great. Student-teachers in stage three (orientation) feel themselves inadequate and incompetent, painfully aware of the complexity of teaching. In the later stages, the student-teachers develop through trial and error, leading to consolidation and mastery at the final stage. To summarize the experience, the first three stages are characterized by much emotional turmoil.

The stages of development described above involve an integration of changes in professional terms as well as personal experiences of stress, feelings of incompetence and changes in the meaning of being a teacher. In the teaching practice period, the student-teachers develop their professional competence and test out their teaching ideas. These experiences of classroom teaching, interacting with pupils and other teachers may bring them feelings of satisfaction, incompetence and loss or relief. This has many implications for the confidence, attitudes, behaviour and performance of the student-teachers as suggested by Diapoto (1980) who finds that student-teachers' attitudes toward teaching and school became less favourable after student teaching.

The school context as constructed by the teachers and school administrators has an influence on the development of the student-teachers in their teaching practice period. Zeichner (1978), in studying the changes in ideology adopted by the students, finds that situational variables, the classroom and school environment, co-operating teachers' attitudes, and the curriculum, have a great impact. Meyer-Smith and Mitchell (1997) conducted a study that aimed to identify the extent to which student-teachers were able to teach with a constructivist view of learning in the teaching practice period after a science method course. The teaching actions, the procedures selected, and how the student-teachers related their practice were studied. A continuum of different degrees of application of the constructivist view of learning in science teaching among the student-teachers was identified. The positive end included student-teachers who demonstrated practice that was consistent and coherent with the approaches advocated in the method course. The negative end included student-teachers who had minimal understanding and application of the approaches. The two groups that were in between the two ends of the continuum showed different degrees of inconsistent practice and occasional applications. The findings indicated that the student-teachers needed support and guidance in order to develop the particular strategy in their practice. The feasibility of the application depends on whether pupils, accustomed to traditional approaches, can accept the new approaches. This can be taken as an influence from the school context on the teaching of the student-teachers. How other teachers in the school have taught has structured the learning habits of the pupils and this influences how far the pupils can adapt to a different teaching approach adopted by the student-teacher. The success of the implementation is also influenced by the student-teachers' knowledge and their beliefs about teaching and learning. Moreover, the research concluded that changes in practice take time and the single method course needs to be coupled with adequate support in the practicum experience in order that student-teachers can experiment with the new strategies advocated in the course. In the present study, this means that the researcher has to consider how the teaching practice and the school context influence the novice teachers, and think about appropriate forms of support to facilitate the development of the student-teachers and the beginning teachers.

In studying how a secondary science teacher changed his beliefs from objectivism to a constructivist view and the implication of this change on his classroom practice, Tobin, Tippins and Hook (1994) identified a number of sociocultural factors that influence the process. These include: the past education and teaching experience of the teacher; the opportunity to observe the teaching of a colleague, the opportunity to reflect on his own teaching; how other colleagues teach science, and the expectations of the students. From a sociocultural view of learning, the interactions between the teachers and students in the school were seen to be contributing to the formation of a culture. At the school level, this culture influences the definitions about the role of teachers and students. At the classroom level, this culture determines what teaching and learning will be like. Moreover, the interactions between other teachers and the students are also mediated actions that influence how individual teachers construct their beliefs about teaching. In the present study, this analysis about how the school and classroom culture influence teaching provides a background for analysing the experience and the development of the novice teachers in the school.

(vii) The need for on-going support

The seventh strategy to keep student-teachers teaching science based on a constructivist view of learning is to provide on-going support as they begin to teach. Continual support for the novice teachers is necessary, as Bell (1993b) pointed out the importance of on-going feedback, support and reflection in helping teachers to develop. Feedback was defined to mean the response given to the teachers, who attempted a new practice, from other parties (Bell and Gilbert, 1996). The feedback may be professionally oriented and include the evaluation of existing practices and the feasibility of new practices. The feedback may also provide personal support and encouragement to the teachers as they attempt new practices. Bell and Gilbert (1996) further explained that the feedback helped the teachers in terms of a sociocultural view of learning as they reconceptualised what it means to be a science teacher, and the interactions with others helped the teachers to reflect on themselves as teachers. Adapting these findings into the context of initial teacher education means that continual interactions with the teacher educator and the peers of the student-teachers during the programme and at the beginning teaching stage are essential to enhance the development of the novices. The feedback helps the novice to develop in three dimensions; professionally through critical discussions about practices; personally through sharing of encouragement and support, and in terms of social development through re-defining their role as science teachers in school. Moreover, continual support is needed for professional growth as Bell and Gilbert (1996, p.97)) suggested: "Innovative teachers and teachers wanting to change their classroom practice need the support of others who value what they are doing." In this sense, novice teachers who are in an active stage of development are strongly in need of continual support, which may come from the teacher educators or their like-minded peers. Through the support, they may feel that their attempts are meaningful, and thus they become more willing to take risks.

To summarize, a number of strategies which help student-teachers to teach based on a constructivist view of learning were suggested in the literature. Firstly, teacher educators need to acknowledge the importance of past experience in the process of learning to teach, and encourage student-teachers to engage in critical discussions or reflections in order to promote changes in their views of teaching and learning. Secondly, teacher educators have to "practice what they preach" and help the student-teachers to develop a pedagogical repertoire in teaching science. By having experienced the learning from the teaching approach advocated, the student-teachers can model the teaching approach and understand the experience as the learner. The significance of the school context in influencing the development of the student-teachers also has to be acknowledged and hence, the importance of on-going support after the novices start their first teaching position is essential. Above all, it is crucial that student-teachers are able to develop their confidence in the teacher education programme. The process of learning to teach involves changing the student-teachers' views of teaching and learning, and this change has to be accompanied by positive changes in confidence to teach science, otherwise it would be difficult to see changes in classroom practice. The next section describes studies of science teaching efficacy beliefs and how they relate to the confidence of teaching science.

2.4.3 Science Teaching Efficacy Beliefs

While the student-teachers learn to teach science, based on a sociocultural view of learning, it is important they feel confident and believe that their teaching will bring about pupils' learning. Teaching Efficacy beliefs measures look into these two aspects: a personal belief about one's own ability to cope with a task (Self Efficacy) and a belief about action and outcome (Outcome Expectancy) (Bandura, 1977). Bandura (1977) hypothesized that an analysis of these two aspects would facilitate the prediction of behaviour. In the present study, this prediction may be applied to reflect how likely the student-teachers or beginning teachers will implement the science teaching strategies developed based on a constructivist view of learning. Teaching Efficacy Beliefs measures are more related to the conation aspect and tends to represent the sense of purpose or motivation of the teacher. This idea is related to the sociocultural view of learning which defines the mind as including three aspects namely, cognition, conation and affect. Although the notion of Teaching Efficacy Beliefs arise from a cognitive view, it is helpful in the sociocultural view of learning as it highlights the conation aspect.

The notion of Teaching Efficacy Beliefs has been further developed since Bandura first proposed it in 1977. Ashton, Webb & Doda (1983) have suggested that Personal Teaching Efficacy is composed of Teaching Efficacy and Personal Efficacy. Teaching Efficacy is comparable to Bandura's outcome expectancy, while Personal Efficacy refers to a teacher's general sense of his / her teaching effectiveness. Ashton et. al. (1983) viewed Personal Teaching Efficacy as an accurate predictor of teacher behaviour, and maintained that the two components of Teaching Efficacy and Personal Efficacy should be kept as separate constructs. Gibson and Dembo (1984) confirmed Bandura's two component model consisting of a) a factor that relates to a teacher's sense of teaching efficacy, or belief that a teacher's ability to bring about change is limited by factors external to the teacher (Outcome Expectancy) and b) a factor that relates to a teacher's sense of personal teaching efficacy, or belief that he or she has the skills to bring about student learning (Self Efficacy). In the present study, the meaning of self efficacy is adapted to reflect the student-teachers' or the beginning teachers' confidence or belief in being able to teach science and effect learning among their pupils. The self efficacy measurement is also taken as an indication of how likely the student-teachers and the beginning teachers will be to teach science with the strategies advocated in the present study, which means teaching science based on a constructivist view of learning.

As Bandura has defined self-efficacy as a general sense of teaching effectiveness, a teacher's overall level of self-efficacy may not accurately reflect their efficacy in teaching Science. Riggs and Enochs (1990) devised the Science Teaching Efficacy Beliefs Instrument, which is composed of two scales, the Personal Science Teaching Efficacy Belief Scale and the Science Teaching Outcome Expectancy Scale, to measure practising elementary school teachers' sense of science teaching efficacy. A similar instrument was also constructed for preservice teacher education students and was applied in predicting science teaching behaviours of student-teachers and in-service teachers (Enochs & Riggs, 1990).

In a study identifying the changes in preservice elementary teachers' sense of efficacy in teaching science, (Ginns, Watters, Tulip and Lucas, 1995), the results revealed that Science Teaching Efficacy and Science Teaching Outcome Expectancy were not significantly correlated, the former being more dependent on personal traits such as internal locus of control and self concept, whereas the latter is related to levels of aspiration, academic interest and satisfaction. The study concludes that the Science Teaching Outcome Expectancy is more easily influenced by the teacher education programme than the Science Teaching Efficacy, as the latter is concerned more with global personality traits. It is, however, the concern of teacher educators to improve the students' sense of Science Teacher Efficacy, as this has implications for the teachers' ability to teach science and the children's ability to learn science (Riggs & Enochs, 1990). Finally, Ginns et.al. (1995) predicted that Science Teaching Efficacy is related to an individual's experience in learning science. For the present study, this means that the teacher education programme may influence the student-teachers' Science Teaching Outcome Expectancy beliefs and the student-teachers' experiences of science learning may be related to Science Teaching Efficacy.

Outcome expectancy and self efficacy beliefs can be applied to predict an individual's persistence of coping behaviour. As Gibson and Dembo (1984) predicted, the construct of teacher efficacy and outcome expectancy would reflect the degree to which teachers believed the environment could be controlled or the extent to which changes in students with given backgrounds can be made. They also suggested that teachers scoring high on both variables will cope with difficult situations with responsiveness, and teachers scoring low will give up readily if they do not get results.

Another direction of self-efficacy research has been to identify the factors that contribute to high science teaching self-efficacy beliefs. Ramey-Gassert, Shroyer and Staver (1996) obtained the personal science teaching self-efficacy and science teaching outcome expectancy scores of 23 elementary teachers. Among the 23 participants, 10 teachers representing a range of levels of personal science teaching self-efficacy and science teaching outcome expectancy were invited to participate in interviews. Analysis of the interview data showed themes related to the scores in personal science teaching self-efficacy and science teaching outcome expectancy. High personal science teaching self-efficacy scores were found among teachers who were described as "strong", self-driven and more independent. These teachers have a positive attitude and employ a minds-on/ hands-on approach in their science teaching. On the other hand, high science teaching outcome expectancy scores were related to having personally experienced success in science and with teaching science. Among these teachers, the belief of students' success in science learning is found to be influenced by the teachers' success in their own science learning and teaching experiences.

In another study, De Latt and Watters (1995) obtained the personal science teaching self-efficacy scores of 37 primary teachers and invited 5 teachers with high personal science teaching self-efficacy scores and 5 teachers with low personal science teaching self-efficacy scores to be interviewed. The interviews were conducted in an attempt to associate scores in personal science teaching self-efficacy with individual teacher's backgrounds, beliefs about teaching science, current classroom science teaching practices, and primary concerns about the teaching of science in the school. Relationships between individual attributes and science teaching self-efficacy were identified, for example, teachers with the highest personal science teaching self-efficacy scores expressed notions of confidence in teaching science, and felt that science was fun and interesting. These teachers were more oriented towards thematic and integrated approaches in science teaching. Teachers with low personal science teaching self-efficacy scores were found to have limited experience in science and their confidence in science teaching was comparatively low. These data provide an association between the quantitative scores and the personality traits, the teaching and the confidence to teach among the primary teachers. In this way, positive changes in scores in personal science teaching self-efficacy and science teaching outcome expectancy can provide an indication of the positive changes in the confidence to teach science, as well as changes in science teaching practices. Moreover, providing positive science learning experiences for the teachers may also be one of the ways to obtain an increase in the personal science teaching self-efficacy and/or science teaching outcome expectancy scores. It is, therefore, of great concern among teacher educators to structure teacher education programmes that provide positive science learning experiences for the student-teachers and to see an increase in the personal science teaching self-efficacy and science teaching outcome expectancy scores among them after the programme.

In this section, the studies have identified factors that are related with high science teaching self-efficacy beliefs. These include personality traits, personal experience of success in learning science, feelings about science, and confidence in teaching science. Moreover, self-efficacy beliefs measures can also be used to predict a teacher's persistence to cope with difficult situations. For teacher educators, self-efficacy beliefs measures may be used to reflect student-teachers' feelings about science, confidence in teaching science and the persistence to cope with difficult situations. In the process of learning to teach, it would be best if re-constructions in views of learning are accompanied by positive changes in the self-efficacy beliefs measures or the confidence in science teaching, and with these changes it would be most likely that changes in classroom practices can occur.

2.4.4 Models of teacher development

In describing the process of learning to teach, models of teacher development may inform the present study in three ways. Firstly, the models may provide a framework for analyzing the development of the student-teachers and the beginning teachers. The framework of analysis may also provide significant indications of the changes and influences. Secondly, models may emphasize different aspects of change, which may capture the characteristic of the development. A mere distinction of pre-service and in-service teacher education or development along a time line oversimplifies the situation. Thirdly, as researchers who aim to build models of teacher development recognize that teacher education is a complex process, representation in models is an attempt to unfold the complexity.

In order to indicate the significance of continual teacher professional development and to describe the characteristics of a professionally satisfactory career and the evolution of instructional skills as teachers become more experienced in teaching, Huberman (1993) built a model of teacher professional development. He views the professional life cycles of teachers as career development, and 'sequences', 'phases' or 'maxicycles' can describe development across different professions. These 'phases' are not necessarily taken as stages but rather as a set of spirals, traversing at different 'elevations'. Characteristic themes of teacher development are identified, namely "survival and discovery", "stabilisation", "experimentation / activism", "taking stock: self-doubts", "serenity", "conservatism" and "disengagement". Among these themes, "self-doubts", "conservatism" and "disengagement" are negative moves. The study also establishes that latter development directions could be predicted based on experience of earlier developmental phases. In conclusion, the study advocates staff development activities that include actual experimentation over time within institutional conditions. In the study, the development of the beginning teachers may be predicted based on their experience in the teacher education programme which is an earlier phase of development.

Another question associated with professional development was whether teachers become more competent and committed with an increase in the number of years of teaching experience. In a recent study in Singapore (Chia, Diong and Toh, 1994) on teacher professionalism, results show that an increase in the number of years of teaching experience does not contribute to the professional development of teachers in the school. Professional development was defined to include teacher competence and commitment to teaching in the study. It remains inconclusive whether this lack of distinction among teachers with different years of experience is due to a lack of "autonomy" among teachers in Singapore schools, or due to a lack of distinction of responsibilities among experienced and novice teachers. On the other hand, teachers who are actively involved in professional development programmes, and those with higher professional qualifications, perceived themselves to have a higher degree of teacher professionalism. These may be different sides of the same coin, as teachers with higher qualifications are those that are "chosen" for professional development programmes and are those that face new challenges like school administrative duties and mentoring duties. To conclude, engagement in continual professional development programmes rather than years of teaching experience is related to professionalism. In the present study, the number of years of teaching is not indicative of teacher development.

Teacher educators must look into the experience of the novice teachers and identify the factors that influence teacher development.

Being dissatisfied with describing professional teacher development as consisting of only three stages, namely, pre-service, induction and the rest of the teaching career, Fessler and Christensen (1992) portrayed a teacher career cycle based on literature and interviews with teachers. The model was built as a guide to understand teachers' career stages, and to point out the implications for teacher development and professional growth. In describing the teacher career cycle, Fessler and Christensen (1992) identified the influences of the personal and organizational environment on the various stages of development. The pre-service stage was described as a period of preparation for a specific role with the developmental target being to learn and apply new theories and practices. The opportunity for reflection on practice and feedback is essential at this stage, while other support may come from friends, family and the teacher education institution. The practice of the student-teachers is seen to be under the influence of both the teacher education institute and the school for the teaching practice period. In helping the student-teachers learn to teach, teacher educators are urged to consider their individual needs. The second stage of development is the induction or beginning teaching stage and is seen as a period when the teacher is being socialized into the system through the learning of the "language of practice". The task of this stage is to gain the acceptance of pupils, peers, administrators and parents. Influences from the personal life at this stage include adjustment to the school community, while influences from the organizational environment include support from the school principal and colleagues. The transition from being a learner (in learning to teach) to being a teacher in the school involves the change from relating theory and practice to socializing into the new school environment. Given the complexity of the responsibilities of a teacher, the researchers urged support from the personal and organizational environments. Unlike the pre-service stage, the support shifts from peers and the teacher education institution to the school principal and the colleagues. More emphasis is placed on the support from the administration and the management of the school, including the principals and supervisors. They are seen as having a key role in establishing a positive climate that facilitates the development of the novice teachers. Learning to teach as a beginning teacher is therefore not only an individual attempt but also a sociocultural process. It involves learning a new language or adapting to a new culture of teaching in the school context in which support from the school environment also plays a crucial role.

Based on the learning and interviews of forty-eight teachers involved in a teacher development project, the "Learning Science Project (Teacher Development)", Bell and Gilbert (1996) constructed a model of teacher development. Three main types of teacher development, namely, social, professional and personal, are described in the model. Social development involves both the renegotiations and reconstruction of what it means to be a teacher, as well as the development of ways of working with others that will enable such reconstruction. Personal development involves managing the feelings associated with changes in teaching and beliefs, in particular when a teacher is using an approach different from the norm. Professional development includes development in instruction skills, gains in academic knowledge, and development of the underlying beliefs and conceptions. This provides a framework or direction for investigations into teacher development in these three aspects. Firstly, studies on development of pre-service teacher education students and beginning teachers can be conducted to describe the changes under each category (social, personal and professional). Secondly, this model addresses the various roles of a teacher - apart from teaching in the classroom, the teacher is also a member of the school staff, a member of a professional community. Hence, the importance of social construction of the knowledge about teaching is emphasized, and teacher development can be explained using a sociocultural view of learning. Teacher development is seen as taking into account the existing experiences and socially constructed knowledge of what it means to be a science teacher. Teachers' knowledge is seen as socially constructed, which provides the context for and the outcome of social interaction among teachers. Thirdly, teacher development is seen as a dynamic process and involves phases or sequences of changes, which involve not only the individual teacher but also other teachers in the school or even the profession.

The staged model of teacher development (Huberman, 1993) looked at the development of the teacher as consisting of a spiral of stages of professional maturity over time. Though this model pointed out that teacher development studies have to include professional development activities over time, the models assume a sequential picture which progresses with the passage of time, with the development involving only the individual. The Singaporean study (Chia, Diong and Toh, 1994) highlighted the importance of continual professional development programmes in stimulating continual teacher development, and concluded that professional growth may not always occur with the accumulation of years of teaching experience. The teacher career cycle proposed by Fessler and Christensen (1992) described the importance of the social environment as the student-teacher transforms to become a beginning teacher in the school. Moreover, a consideration of teacher development in terms of professional, social and personal development provides a framework to study teacher learning. Based on this framework, the development of a teacher can be defined, described and studied. This also provides the backbone for designing attempts to facilitate teacher development and in analysing teacher education. The emphasis on the sociocultural view of learning and the importance of socially constructed knowledge of what it means to be a teacher form an important basis in understanding teacher development.

2.4.5 Teacher socialization

Teacher development is seen as a process that involves the social construction of the knowledge of teaching and what it means to become a teacher. Based on a sociocultural view of learning, teaching and learning is a process that involves not only the individual teacher but also other teachers in the school context. Similarly, teacher educators (Zeichner and Gore, 1990; Duesterberg, 1998) view teacher socialization as a process in which the novice teachers are socialized into the community of teachers in the school. Studies on teacher socialization provide information of how beginning teachers undergo changes in their professional practices and more importantly, these studies analyse how the school environment consisting of the socializing agents - the colleagues and school administration - influence their development. According to Deal and Chatman (1989), the definition of organisational socialization consists of three processes. Firstly, it is one that involves the transformation of being an outsider to being an effective insider. Secondly, it involves the teaching of new members about the existing culture, and the learning of the individual's role. Finally, it is a process that involves the learning of the values and the norms of the organisation. This analysis is comparable to a sociocultural view of learning based on which Rogoff (1995) suggested to analyse these processes using three planes of analysis; apprenticeship, guided participation and participatory appropriation. These planes may be applied to study teacher development and interpret the teacher socialization process. For the beginning teachers, the organization is the school, and these learning processes include interactions with other participants in the community including other teachers, the pupils, and the school principals. Moreover, the interactions between the novice teachers and the participants lead to new consequences and implications for their classroom practice. The following review includes an introduction to the changes in teaching during beginning teaching, the roles of the various socializing agents, that is the colleagues, the school administration and the beginning teacher, and models of teacher socialization.

2.4.5.1 Teaching and Beginning Teachers

The problems that beginning teachers have in teaching are extensively described in the literature. For the present study, the problems highlighted the constraining factors of the school context on teacher development. The extent of these problems may also influence how ready the novice teachers are to teach science with a constructivist view of learning. Day and Hadfield (1995) described the primary teachers' thoughts about teaching as involving "the head and the heart", which describes the difference and the dilemma between the "actual" and the "ideal" images of the teachers themselves. This points to the phenomenon that the teachers are unable to put into practice their teaching intentions. Classroom management problems are common (Cooke and Pang, 1991). There are others, as Goodman (1987) and O'Neal and Hoffman (1984) described beginning teachers as becoming managers of predetermined programmes, rather than practitioners of innovative strategies. Beginning teachers were found to adopt traditional methods of classroom control in a study by Vonk and Schras (1987). The "actual" or the realities of teaching are under the influence of the school context. The influence may be enhancing or constraining of the teaching of the beginning teachers.

While there are studies that addressed the problems of beginning teachers (Veeman, 1984), and described teacher developments in terms of shifts in teacher concerns (Lin and Yang, 1995) in which trends of problems and concerns seemed to be shared widely by beginning teachers, teaching is seen as being largely influenced by the specific contextual situations. For example, in studying beginning teachers' learning, Busher, Clarke and Taggart (1988) found that the novices found themselves heavily constrained by the norms and expectations of the school, parents and the public about how teachers should teach, and what pupils should learn. In their study, some of the beginning teachers were left to find their own way of teaching, and others worried about conforming pupil activity to school expectations. Duesterberg (1998) offered a theoretical perspective in explaining the teaching of the beginning teachers with a concept of cultural identification. Cultural identification is a process in which the individual has to identify with particular practices and decide whether he or she is going to fit into the school culture. The decision involves overcoming the fear of difference, and determining the boundaries of being normal or different. The setting of the boundaries involves not only the individual teacher but also the school and the community. In this line of thinking, the school or the community contexts significantly influence the teaching of the beginning teacher. Being different from other teachers includes surmounting the accompanying fear. In cases where their teaching is considered to be different, the beginning teachers are at a crossroads between identifying with the school culture and the construction of their own identity. Congruent with a sociocultural view of learning, Liston and Zeichner (1991) urged researchers to consider teaching as a situated activity. They encouraged teacher educators to heighten their focus on the political, social and institutional contexts of teachers' actions, as well as the consequence of the teachers' actions. Taking this perspective, teacher's actions should then be considered in light of the school and classroom contexts. Studying the process of socialization or learning to teach in the school context for beginning teachers, needs to include an examination of the influences of the pupils, other teachers in the school, and the school principal.

2.4.5.2 Agents of Socialization and their influences on Beginning Teachers

Although the agents of socialization include both people within and outside the school, this review focuses on the four main agents in the school context, namely, the principal, the colleagues, the pupils and the teacher himself or herself. These are the likely agents that are to be involved in the social construction and re-construction of the knowledge about teaching, and the meaning of a science teacher in the present study. Zeichner and Gore (1990) suggested the exploration of the influence of the school culture on the beginning teacher. School culture was defined as policies, tradition, power and personalities in the school context. A study by Johnston (1981) has explored how beginning teachers viewed themselves in fulfilling their roles within the school context. The beginning teachers reported strong positive changes in their relationships with fellow faculty members, students and, to a lesser extent, parents. However, teachers reported having increased difficulty in their relationship with the principal. Organizational constraints and role differences greatly affected their relationship, as principals have an evaluative role which increased the beginning teachers' anxiety. Moreover, researchers have found that principals indirectly affect the socialization of new teachers by setting expectations (Rosenholtz, Bassler, & Hoover-Dempsey, 1986; Zeichner & Tabachnick, 1985), determining classroom tasks, handling disruptive students and their parents, providing opportunities for professional development (Wildman, Niles, Magliaro and McLaughlin, 1989), and determining the amount of autonomy teachers have (Kilgore, Ross & Zbikowski, 1990).

Colleagues influenced the beginning teachers in positive ways, namely, in developing their teaching skills, in acquiring a sense of competence, and in acting as role models. Conversely, if the colleagues are unsupportive, there are also negative influences. On the positive side, Rosenholtz, Bassler & Hoover-Dempsey (1986) found collaboration with colleagues important in teachers' perceptions of successful skill acquisition. Olson and Osborne (1991) explained that there is a need for affiliation or feelings of being a member of the teaching staff for beginning teachers, and this affects their sense of competence and security. Wells (1984) found that teachers are more likely to act as role models if they are in a position to evaluate the beginning teacher and have established a friendly relationship with the individual. Role models have a significant effect upon the individuals' adoption of teaching strategies and values. On the negative side, a number of unsupportive behaviours of colleagues have a negative impact on how new teachers view themselves and their work, and that can ultimately contribute to their leaving the profession (Applegate, Flora & Lasley, 1980). Vonk and Schras (1986) found that co-operation between colleagues was not stimulated in schools. Most beginning teachers in their study characterised their contacts with colleagues as being rather formal, on the surface and businesslike. In this situation, beginning teachers work on their own, and Vonk concluded that this resulted in the development of the "lonely teacher". The "lonely teacher", or having distant teacher relationships, was not considered to be a supportive condition for the professional development of the novices or even for other experienced teachers in the school. In view of this finding, Vonk suggested that collegial coaching or support is to be encouraged in order to help the beginning teachers to integrate the newly learnt knowledge and skills.

Pupils are both sources of support and frustration for beginning teachers. In qualitative research by Wildman et al. (1989), students were identified as the most influential factor in teachers' early career development. The study found that the extent to which new teachers' incoming beliefs and expectations were confirmed had a significant impact on subsequent teaching perspective, self-confidence and job satisfaction. Etheridge (1989) concluded with a similar dynamic situation. She argued that the beginning teacher makes strategic adaptations to their instructional strategies based on their dialogue with students. Vonk and Schras (1986) have illustrated this dynamic in more concrete terms. They concluded that pupils' reactions affect the beginning teachers' attempts at innovative teaching methods. Usually the beginning teachers had insufficient insight into the problems the students were experiencing. Consequently, they experienced failure in attempting innovative teaching methods, mostly due to discipline problems. Finally, the beginning teachers may resort to traditional teaching methods and some teachers felt forced into that situation by their students. Blase (1986) described such situations, which are related to classroom management and instruction, with teachers becoming more conservative with "rationalization of teaching", a process involving "long term teacher adjustments".

As shown by the above review, the school context has been shown to have a large influence on the development of the beginning teacher, and individual characteristics and perspectives are also documented as very significant factors. The emphasis on the interaction between the context and the individual has called for a reconceptualization of the teacher socialization theory (Crow, 1986). Kilgore, Ross and Zbikowski (1990) found that beginning teachers play an active role in their process of socialization, and this may lessen the effect of the contextual factors. In their study, the novices' personal commitment and self-confidence helped maintain a reflective approach to teaching, even when they were confronted with unsupportive environments. The novices had a strong set of ethical beliefs and viewed their problems as situational, not as indicative of their inability to teach.

While the influences of the various agents on the socialization of beginning teachers are discussed, the result of the interactions depends on individual situations, and the direction of change is not conclusive as these may enhance or deter teacher development. Despite the variety of possibilities and influences operating simultaneously, a number of attempts were made to describe the process and the models of teacher socialization.

2.4.5.3 Models of teacher socialization

While teacher development can be seen as a social process, an exploration of the role of the individual in relation with his/her interaction within the school context is essential. Models of teacher socialization attempt to explain the process as an individual or a social process, and the role of the individual either as a passive agent, totally under the influence of the school context, or as an active agent who interacts with or may even change the school context. The latter view coincides with a sociocultural view of learning where the interactions between the individual and the social surround is emphasized and these interactions may result in changes in both parties. Liston and Zeichner (1991) identified two extremes of educational research which were composed of the holistic and the individualistic view on either end of the continuum. The individualistic view, or the psychological perspective, has been criticized for overlooking the importance of the social context, which constrains and enables individuals. On the contrary, the holistic view was equally inadequate as it gave too much power to the social whole, without acknowledging or accounting for the functions of the individual. As both extremes seem unsatisfactory, a third view called a "synthetic approach" was introduced, which takes into account the interactions between the teachers' actions and the institutional context. It was stemming from this approach that Liston and Zeichner (1991) called for the study in teacher actions as situated practice, as outlined in the previous section. This approach of looking at the synthesis of the social context and the individual actions is also known as the dialectic approach. On a similar track, studies in teacher socialization account for the process in two extremes, the functionalist and the dialectical perspectives. The functionalist perspective considers teachers to be passive objects of socializing agents (Parsons, 1951) wherein "socialization fits the individual to society" (Lacey, 1977 p. 18). Novice teachers were seen as individuals who internalize and import the external values into their practice. However, the dialectical perspective takes on a very different view, as explicated by Zeichner (1980, p.22). It is "a more complex, interactive, negotiated, provisional process...that stresses the importance of man as a creative force, as a searcher for solutions and as possessing a considerable potential to shape the society in which he lives". In this perspective, the importance of interaction between the individual and the context is stressed and viewed in a multidimensional aspect. The emphasis on the interaction between the individual and the context is consistent with a sociocultural view of learning.

An alternative way of studying teacher socialization is to regard the school as a workplace, and to analyze teachers' actions with reference to the conditions of work. Taking the school as a workplace, Liston and Zeichner (1991) summarized a number of studies that reveal the school conditions as constraining rather than enabling most of the time. They cited Gutmann's (1987) work, which suggested that many teachers are overworked, emotionally drained, and lack the time and support to complete their educational tasks. Moreover, Feiman-Nemser and Floden (1986) have also pointed out that teachers work mostly in isolation in their own classrooms where there is little interaction with other adults. Teachers interact with the school principal in two ways. While they do not want to be interfered with in their teaching, and yet they want the principal to act as a buffer to the outside world. Understanding the school as a workplace provides an alternative perspective for looking into teacher socialization and the learning process of the novice teachers.

In actual fact, student-teachers are not exposed to the classroom or school situation only after they become a member of the teaching staff in school. Learning to be a teacher starts from early education experiences during which the children can be regarded as observing teaching. Teaching is regarded to be a profession in which the participants undergo the longest period of observation before their practice (Schempp and Graber, 1992). During this period of observation, viewpoints about the teaching role are built through the internalization of classroom experiences. This period was referred to as anticipatory socialization (Burlingame, 1972), pretraining (Zeichner and Gore, 1990) and the apprenticeship of observation (Lortie, 1975). From a sociocultural point of view, this is an apprenticeship period (Rogoff, 1995) when the individual interacts with the community and is introduced into the practice of the community. From a constructivist view of learning, this is regarded as preconceptions that the student-teachers held before they entered the teacher education programme, which will be changed and developed into new conceptions about teaching and learning. Having these views of learning in mind, the role of the teacher educator is to be aware of the importance of these experiences and how they influence the learning process of the student-teachers.

2.5 A summary of the literature review

This section provides a summary of the studies discussed in the above literature review, in particular, the review on the sociocultural view of learning and its implications for teacher education. The learning of the student-teachers and the beginning teachers in science teaching can be informed by a sociocultural view of learning. As the personal constructivist view considers that the learners hold prior experiences or ideas that influence subsequent learning, or in the case of the novice teachers: their teaching, this view only partially informs the study. The sociocultural view provides a more comprehensive picture in explaining the process of learning to teach. The sociocultural view of learning informs the present study in the following ways:

i. Knowledge about teaching is socially shared among the teachers in the profession and in the school. Novice teachers learn and may also transform this socially shared knowledge about teaching.
ii. Learning in a teacher education institute is contextualised in the teacher education programme and the student-teachers have to re-contextualize their learning to the school and classroom context.
iii. Learning to teach can be explained by using an apprenticeship, guided participation and participatory appropriation planes of analysis (Rogoff, 1995). The first plane of analysis explains the interactions between the agent and the learner at a community plane. The second plane of analysis emphasizes the coordination and communications at an interpersonal plane where the agent acts as a guide or mediator for learning. The third plane of analysis emphasizes the active role of the novices and their changing roles as learners and transformers of knowledge.

Based on the sociocultural view of learning, a number of strategies for the teacher educator, that may facilitate the student-teachers and beginning teachers in learning to teach science, can be summarized:

i. Teacher educators need to acknowledge the importance of the past experience of the student-teachers as their prior education experience may influence their learning.
ii. Teacher educators need to "practice what they preach", that is to teach the student-teachers with an approach which they themselves advocate. This models the teaching and helps the student-teachers to experience what learning feels like. This helps to socialize the student-teachers into the teacher education and school context. This may also be considered actively mediating the novices between their existing ideas of teaching to new ways of science teaching advocated in the programme.
iii. Student-teachers need to be encouraged to reflect and discuss with their peers as well as the teacher educator in the process of learning to teach. The discussion helps to shape their ideas and compare their thinking. The novices are interacting with others at the intermental plane while reflecting on their own at intramental planes.
iv. The programme needs to be structured to provide positive science learning

experiences such that the novices may gain their confidence in teaching science. This may be shown by an increase in the scores in Personal Science Teaching Efficacy Beliefs.

v. The student-teachers needs to be encouraged to develop a repertoire of science teaching activities and use them according to the classroom context and in a way that helps pupils to develop their science concepts.

vi. The teacher educator has to be aware of the influences of the school context, namely, the pupils, other teachers in the school, and the school principal, on the teaching of the novices. As the novices begin to teach in the school, they are involved in a process of teacher socialization which can be viewed as a functionalist or a dialectical process. The latter assumes a more active role among the beginning teachers and is consistent with the sociocultural view of learning.

vii. Ongoing support and continual interactions with the teacher educator and the peers of the student-teachers during the programme and at the beginning teaching stage are essential for enhancing the professional development of the novices. These interactions also provide chances for reflection. The teacher educator may provide opportunities for interactions as mediated actions.

viii. Teacher development may be viewed as including professional, personal and social development.

The sociocultural view of learning informs the present study both by explaining the learning process of the novice teachers as well as guiding the practice of the teacher educator in facilitating the learning of the novices.

2.6 Aims of study

There were two aims for the study. The first aim was to find out ways to facilitate the development of the student-teachers' and beginning teachers' ability to teach science in schools, so as to engage the pupils in thinking during the lessons, and to use teaching activities based on a constructivist view of learning. Secondly, the present study aimed to understand the learning process of the novice teachers, in terms of their development and the influences that may be acting on their development during the period from student-teaching to beginning teaching.

2.7 Research questions

The following are the research questions that framed the present study:

1. What are the ways that can enhance the novice teachers' ability to teach science based on a constructivist view of learning in the initial teacher education programme and in beginning teaching?
2. In what ways did the student-teachers develop professionally, personally and socially (Bell and Gilbert, 1996) as they progressed through the initial teacher education programme and the beginning teaching?

Chapter 3

Methodology

This chapter describes the method of research and the data collection. As the focus of the study is to find out about the development of the novice teachers and to understand their learning process, the main sources of data are the beliefs, the experiences and feelings of the individual participants. Moreover, the intervention of the study aimed to try out ways of better preparing student-teachers to teach science based on a constructivist view of learning. The following sections of this chapter describe approaches to social science studies, the three phases of the study, data collection methods, data analysis, intervention strategies and ethical considerations made in the study.

3.1 Approaches and methods in social science research

This section describes the approaches to social science research and compares the meaning of data, the method of analysis and how theory is derived under the different approaches. By using a sociocultural view of learning to analyse teacher development, the present study adopted an interpretive approach to find out how the participants made sense of their experiences as they were socialized into a culture of teaching. The second sub-section looks into the qualitative and quantitative methods, and considers how each of these contribute to the interpretive approach. The third sub-section focuses on the specific method of data collection employed in the present study.

3.1.1 The positivist, interpretive and critical social science research approaches

Three approaches to social science research were described by Neuman (1997) namely, positivist, interpretive and critical social science approaches. A comparison of the three approaches as described by Neuman (1997) is summarized in the following paragraphs.

The positivist social science approach is congruent with the ontology and epistemology of methods of investigation in the natural sciences. This approach is described as "objective" and "value-free". Data collection techniques are associated with surveys and experiments. Data analysis techniques are associated with statistics, and testing out hypotheses by using numbers or exact measurements. The observations made must be replicable and the explanations made must have no logical contradictions, and must be consistent with the observations. Critics have found that the positivist approach cannot reflect the actual lives of people as it does not provide information about the interactions of individuals and human beings (Neuman, 1997).

The interpretive social science approach views social reality as constructed by people. In contrast with the positivist approach, interpretive researchers do not emphasize replication or objectivity, as every person's definition and experience of social reality is seen to be different, and varies from time to time. This approach aims to describe how different people experience the world, create and share meanings. The description provides others and the readers with a feel for the social reality experienced by different people. Unlike the positivist, the interpretive researcher does not attempt to be value-free.

The critical researcher starts with a point of view (e.g. feminist) and describes issues associated with role and power that are ignored by the interpretive researcher. The interpretive researcher differs in the way that their study provides an account of the rules of behaviour, interpretive mechanisms and systems of meanings, and does not necessarily hold a particular point of view at the beginning of the study. The aim of the critical researcher is to change society radically and to develop a critique that helps people to see the way to a better world. Values and positions are divided into right and wrong.

The present study adopts an interpretive approach rather than a positivist or critical approach. By taking an interpretive approach, the present study explains the world not by means of abstract, logical theories, but instead attempts to understand the actions of the student-teachers: how they described their experience and their feelings in the process of learning to teach. Congruent with a sociocultural view of learning which was taken to analyze student-teachers' development, the interpretive approach acknowledges that people create their understandings of the reality in their social interactions with others. In using an interpretive approach, the description of the reality in the present study did not consist of deductive theorems, but included inductive descriptions and interpretations of how the participants of the present study conducted and make sense of their lives. The evidence or data were interpreted in the light of this context. People's actions and descriptions were understood in the light of the contextual situation. The present study is also different from the critical approach in that the aim was to understand and describe student-teacher development as viewed by the participants, instead of attempting to put forward a radical point of view that changes society. Values were seen only to be different, instead of being right or wrong as suggested by critical researchers.

3.1.2 Qualitative and quantitative research methods

In drawing a relationship between the three approaches discussed in the previous section: positivist, interpretive and critical social science research approaches, and the quantitative and qualitative research methods, Neuman (1997) suggested that the positivist approach tends to be associated with quantitative methods whereas the interpretive and critical approaches tend to be related with qualitative methods. Although the quantitative and the qualitative methods of research seem to be distinct from each other in how the researcher sees data, Neuman (1997) suggested that all researches are a mix of both quantitative and qualitative types, with the proportion of each type varying. Researchers can employ mixed-methods designs by using both qualitative and quantitative methods to look at different aspects of a problem (Crawford and Christensen, 1995). This is feasible because each method contributes a different part of the picture, while both methods may reliably be used to understand the constructed realities of the people or activities in the study, as well as generate data that may be generalised (Drew, Hardman and Hart, 1996).

The present study adopted an interpretive approach. As suggested by Neuman (1997), most studies involve a mixture of quantitative and qualitative methods, with both methods of data collection being employed. Despite this, the main part of this study is qualitative in nature, and phase three of the study adopted a case study approach. The use of the qualitative method is consistent with the interpretive approach, as both emphasize the importance of the social context in understanding the social world and how the participants make meaning of their experience. The teaching and learning of the student-teachers were explained and described in the light of the social context of the teacher education institute and the schools. The explanations may have been different if the teaching and learning had occurred in different situations. This is congruent with a sociocultural view of learning, which was employed to explain the results of the study. The qualitative method used within an interpretive approach is consistent with a sociocultural view of learning. Both consider people's actions in the light of the context or the purpose behind it; for example, in explaining the function of a resource pack, the pack has to be viewed together with the intentions based on which the contents are designed.

Consistent with the above comparisons, three strengths of qualitative research have been identified by Miles and Huberman (1994). Firstly, qualitative data were found to reflect actions instead of behaviour. Congruent with a sociocultural view of learning, actions were defined as carrying with them the intentions and meanings of the actor. Secondly, these actions were context specific and hence reflect what "real life" is like. Thirdly, the strength of the qualitative data is the fact that it reveals the meanings that people give to what happens around them, or the "social world". This is comparable to a social constructivist view that values how people interact with each other and build up shared meanings about reality. In line with these arguments about the strengths of qualitative studies, the present study described the teaching actions of the teacher educator, the student-teachers and the beginning teachers. Their actions were analysed embedded in the social context, namely, in the teacher education institute and the schools. The interactions between the participants and the researcher, as well as between the participants and the schools, were analysed and valued.

3.1.3 Data collection methods employed

A study that involves the same group of participants, with data collection lasting over a period of time, is described as a cohort study or longitudinal design. The present study is a cohort or panel study in which the professional, social and personal developments of the student-teachers were followed over a 21-month period. The strengths of a cohort study are identified by Cohen and Manion (1994) as being capable of constructing patterns of development, producing individual growth patterns, and being able to distinguish 'real' changes. It also eliminates the influence of limited time associated with one-off studies. Moreover, Shaughnessy and Zechmeister (1996) suggested that longitudinal studies are crucial in studying changes over time. As the present study is designed with a purpose to describe student-teacher development, it identifies with the nature of cohort study. The advantage of a longitudinal design coincides with the purpose of the present study, that is this design allows the researcher to determine the direction and extent of change for individual participants (Shaughnessy and Zechmeister, 1996).

Research studies with a longitudinal design need to face a potential problem that the number of participants may be low (Shaughnessy and Zechmeister, 1996). At the commencement of the study, it can be difficult to find a group of participants who are willing to be involved in a long-term study, in which they may have to fill in surveys over a number of years. During the course of the study, the number of participants may decrease due to mortality. This mortality includes both a literal and figurative meaning. Another problem associated with longitudinal studies is that repeated interviews may have an influence on the participants. They may strive to respond in consistent ways or the first interview may sensitize the participants to the issue being investigated (Shaughnessy and Zechmeister, 1996). For example, having been prompted to discuss teaching science with a constructivist view of learning in the interviews, the student-teachers may attempt this strategy more frequently in their classroom teaching. Despite this, these attempts of the student-teachers may not be interpreted as a negative influence as this was the aim of teacher education.

Having set the main approach and method of the study, the following section describes the different methods of data collection, including: survey for field research, interviews, classroom observations and journals.

The major portion of the qualitative data in the present study was collected using interviews, classroom observations and journals. Through the interviews, data was gathered through direct verbal interactions, and this allowed a greater depth of data collection (Cohen and Manion, 1994). Furthermore, the use of interviews in the present study was consistent with Neuman's (1997) summary of the typical field interview:

- The questions and the order in which the questions are asked are tailored to specific people and situations.
- The interviewer shows interest in responses which encourages elaboration.
- It is like a friendly conversational exchange, but with more interviewer questions.
- Open-ended questions are common, and probes are frequent.
- The interviewer and member jointly control the pace and direction of the interview.
- The social context of the interview is noted and seen as important for interpreting the meaning of responses.
- The interviewer adjusts to the member's norms and language usage. (Neuman, 1997, p. 371)

These points reflect the importance of the context in the interviewing process and in the interpretation of the interviewing data. The importance of developing trust, a potentially long-lasting relationship and encouraging openness for the interview process was pointed out by Reinharz (1992). Moreover, the importance of a non-hierarchical relationship between the interviewer and the interviewee has been highlighted by researchers (Oakley, 1981; Haig-Brown, 1992). While field interviews are described as being unstructured, informal and long, the interviews in the present study were semi-structured with the interview schedule constructed in accordance to the three areas of teacher development. Despite this, the interviews were in-depth, open ended without prescribed categories of responses, and to some extent unstructured as the participants were given the freedom to elaborate on issues they felt to be significant to their development.

Part of the data was obtained by observations in the classroom. Observation involves the collection of data on non-verbal behaviour, and is seen as a method superior to surveys as it is less reactive and it eliminates verbal bias in structured questions. Further, this method allows researchers to make appropriate notes and describe ongoing behaviour which takes place in a more natural environment. A more intimate and informal relationship between the researcher and the participants of the study can be developed over an extended period of time (Cohen and Manion, 1994). Realising the above summary of the inherent advantages of observation, the present study incorporated observation data in relation to interviews and journals in describing the actions of the novice teachers. It is not only the behaviour that was described but the views and intentions of the novice teachers were analysed thus providing a description of the actions.

Apart from having the novice teachers talk about their experiences in interviews or observing them in classrooms, the collection of journals provides valuable descriptions about how they think about their own experiences. The use of "subject's written words" as a form of data is found to be a rich source of data and their use is often coupled with interviews and observations (Bogdan and Biklen,1992). Moreover, Mikkelsen (1985) found journals to be a useful tool in studying teaching as they may reflect how student-teachers make links between theory and practice. In the present study, the data from the observations, interviews and journals were to be interpreted in a coherent way to provide a portrait of the development of the novices.

The design of the present study allowed triangulation of various sources of qualitative data as obtained from interviews, classroom observations and journals. The use of different data collection techniques can serve to eliminate bias and overcome the problem of 'method-boundedness' (Cohen and Manion, 1994), that is to be limited by a single method of data collection. Moreover, qualitative data was supplemented with quantitative data from a survey or questionnaire study. Neuman (1997) summarized from selected studies (Agar, 1980; Smith, 1987;

Smith and Gene, 1987) and concluded on how surveys can complement field or qualitative research. Among Neuman's comparisons, three were particularly relevant to the present study:

- Corrects for the tendency to see parts of a setting as congruent.
- Demonstrates that a single observation may be generalizable.
- Verifies field observations and interpretations. (Neuman, 1997, p.337)

The quantitative measurements of science teaching efficacy beliefs reflect the changes in confidence to teach science among the participants in the study. These measurements were compared with the emergent themes in the qualitative data, and allowed the findings to be generalized to other participants in the study who did not participate in the interviews. Moreover, the changes in the trends of the science teaching efficacy beliefs measures verified the interpretations drawn from the classroom observations and the interviews. The use of both quantitative and qualitative data in a study was described as linking the two types of data by Miles and Huberman (1994). They related that the analysis of quantitative data helped to show the generality of the observations from the qualitative part of the study and reduced the "holistic fallacy (monolithic judgement about a case)". A one-sided view on judgement is avoided as the quantitative data may help to verify or provide new interpretations of the qualitative findings.

The linking of the two types of data was also depicted at three levels, two of which are relevant to the present study. One of the levels involves the linkage of two types of data as described above, in which quantitative data were used to support the findings in a qualitative study. Another level is the "quantizing" of qualitative information, thus making qualitative information countable. For example, this involved counting the frequency or the occurrence of a certain response in the interviews. Instead of showing the relationship between the two methods of data collection, this level described how qualitative data could be analysed with representations in numbers.

Consistent with the adoption of an interpretive approach, the data collected in the present study involved a combination of qualitative and quantitative methods, with the latter supporting the findings in the former. As a longitudinal study, it was a cohort or panel study, which involved the same group of participants throughout the period of study. The qualitative methods of data collection included interviews, classroom observations and journals. Having described the methods of data collection, the following section looks into the three phases of the study.

3.2 The three phases of the study

In order to prepare the student-teachers to become better science teachers, the intervention strategy of the presented study was conducted in 3 consecutive phases: the curriculum studies module, the teaching practice, and the beginning teaching over a twenty-one month period. The interventions actually included the various forms of support for the participants at the different phases (Table 3a). During the Curriculum Studies module, the interventions mainly included ways that helped the student-teachers to be aware of the importance of children's preconceptions and to teach based on a constructivist view of learning. During the teaching practice, the interventions provided opportunities for the student-teachers to support each other and discuss their choice of teaching strategies. During the beginning teaching phase, the intervention mainly consisted of the provision of the resource packs, the workshops and telephone enquiry opportunities.

The data were collected in pace with the interventions and included both quantitative and qualitative methods (Table 3b). During the teaching practice and the beginning teaching phases, lesson observations were made. Other forms of data collection included the use of questionnaires, interviews and journals.

Having described an overview of the study, the following sections describe in detail the data collection adopted to portray teacher development, and the intervention strategies that aimed to enhance teacher development.

Table 3a The three phases and the interventions in the study

Phase	Activity	The interventions that supported teacher development
1 Sept to Jan, 1997	Module on science curriculum studies (CS module)	1. Helping student-teachers to be aware of the influence of their previous (science) education experience 2. Strengthening pedagogical content knowledge, raising the awareness of children's preconceptions 3. Discussing characteristics of science teaching: pictures of teaching situations, use of concept maps, videos of sample lessons (stating the characteristics), card sorting, power on/off/with/for, post-box 4. Discussing ways to develop children's ideas and carry out follow-up investigations 5. Discussing planning and teaching science 6. Microteaching
2 March to May, 1998	Teaching Practice	1. During the Teaching Practice: - discussion of alternative ways of teaching - encouragement from peers 2. After the Teaching Practice: - experience sharing
3 Sept, 1998 to June, 1999	Beginning teaching	1. Workshop on the resource packs -- to exchange ideas in teaching; suggesting problems and solutions 2. The resource packs 3. Telephone enquiry

Table 3b A summary of the three phases and the data collection methods

Phase	Activity	Data Collection
1	Module on science curriculum studies	1. Invitation to participate in the study 2. Recordings of sessions 3. Questionnaire 4. Interviews (before and after teaching the module)
2	Teaching Practice	1. Interviews after the teaching practice 2. Classroom observations 3. Questionnaire
3	Beginning teaching	1. Interviews after 3 months of teaching and during the implementation of the resource packs 2. Classroom observations 3. Questionnaire 4. Journals

3.3 Data collection

The design of this study involved both qualitative and quantitative methods of data collection. The qualitative data were collected to reflect the professional, social and personal development of the student-teachers and the beginning teachers. The quantitative data were collected to represent the changes in the confidence to teach science and the perceptions among the novice teachers about science teaching. Qualitative data were acquired through interviews (Appendix A1 to A6), field notes, journals (Appendix B1, B2) and observations. Quantitative data were obtained through the use of the student-teacher background questionnaire (Appendix C1), the science teaching efficacy belief (STEB) instrument (Appendix C2), the science teaching questionnaire (Appendix C3), the post questionnaire teaching practice (Appendix C4), and the beginning teaching questionnaire (Appendix C5).

The data was collected by the researcher, who was also a lecturer teaching the group of participants, i.e. the student-teachers in the teacher education programme. This teacher educator role motivated the study. The researcher role was kept more prominent in the data collection in a number of ways. Firstly, data collection was separated from assessment. The involvement of the researcher as a lecturer was limited to the two-credit point Curriculum Studies module, and within that module the researcher was involved in the assessment of the student-teachers. The assessment took the form of the trying out or micro-teaching, and a test during the last session of the module. Data was not collected during the sessions when assessment was taking place. During the teaching practice period, the researcher collected data through lesson observations with the student-teachers. As the assessment for the teaching practice was conducted separately from the other parts of the programme, the researcher did not play a dual role as an assessor while data was collected in the lesson observations. Throughout the period of the study, the researcher separated the data collection procedures from the assessment of the student-teachers. Despite this, the researcher was aware of the possibility that the student-teachers might respond in ways that closely corresponded to what was taught in the module. To minimize this possibility, the student-teachers were reminded in the interviews and in filling out the questionnaires that they were part of a research project which had no bearing on their assessment of the module. Secondly, the researcher reminded the participants about the confidentiality and anonymity of the data collected. In the interviews, the student-teachers were assured of the confidentiality of their identity and of the purpose of the data collection. Thirdly, the researcher tried to build up a trusting relationship with the participants. The interview process was more open and informal (compared with a general lecturer-student-teacher relationship) and the dialogue was more like a daily conversation. The researcher also attempted to conduct the interviews in a non-hierarchical atmosphere. The student-teachers were encouraged to express their views honestly and openly about the Curriculum Studies module and about their teaching during the beginning teacher phase. Due to the research, there was more contact between the researcher and the student-teachers which helped to build up trust among the student-teachers. This trusting relationship was more prominent in phase three, the beginning teaching phase of the study, when the student-teachers had graduated. The beginning teachers were more ready to voice their concerns, to talk about how other teachers taught in the school and their feelings, and to take risks in implementing changes in their science teaching. At the beginning teaching phase, the researcher did not play a dual role but was more of a peer or a friend to the beginning teachers, supporting them informally in their science teaching.

3.3.1 Participants

The participants were the final year student-teachers of the two-year Certificate in Primary Education Programme at the Hong Kong Institute of Education. A total of 39 student-teachers took the Curriculum Studies module, all of whom were taking science as their main curriculum area. Table 3c represents the number of participants in the qualitative part of the study. There were 13 student-teachers who volunteered to participate in the interviews before the commencement of the module. During the teaching practice, only 11 of them had a chance to teach science topics and hence participated in the interviews. Among the 11 student-teachers, only five of them managed to secure a teaching post in primary schools. The others were either teaching in special needs schools or did not manage to find a teaching post. As the curriculum and the classroom situations in the special needs schools[1] were quite different, only five of the beginning teachers were included in the last phase of the study.

Table 3c The number of participants in the qualitative part of the study

Phase	Number
Before and after the module	13
After the teaching practice	11
At the beginning teaching phase	5

The number of respondents in the quantitative part of the study at the different phases is summarized in Table 3d. The questionnaires were sent out to all the student-teachers (N=39) in the first session of the Curriculum Studies module. The student-teachers were invited to fill in the questionnaires in the last session of the Curriculum Studies module. As three student-teachers were absent, a total of 36 questionnaires were collected. Another questionnaire was mailed to the student-teachers after the teaching practice, and a reminder was sent to those who did not return the questionnaires after one week. Finally, 27 returned the questionnaire. According to the returns after the teaching practice, 20 of the student-teachers taught science during their teaching practice.

Table 3d The number of respondents in the quantitative part of the study

Phase	Number
Before studying the Curriculum Studies module	39
After studying the Curriculum Studies module	36
After the teaching practice	27
Student-teachers who taught science during the teaching practice	20

3.3.2 Qualitative measures

The qualitative measures in the present study include findings from the interviews, classroom observations and journals as described in the following sub-sections. The planning of the qualitative data collection was made with consideration for an adapted cycle of teaching (Figure 3a) as suggested by Shulman (1987). The cycle includes the selection of teaching material, the selection of instructional strategy (or teaching approach), classroom teaching, and

1 The special needs schools are set up for children with special mental and physical needs. The curriculum, the ability of the pupils and the classroom situations are very different from the primary schools.

how teachers think about their teaching. Based on these, the interview included questions on lesson preparation, the choice of teaching strategies, and how the teachers think about pupils' learning. Moreover, the lesson observations conducted looked into the classroom teaching part of the cycle.

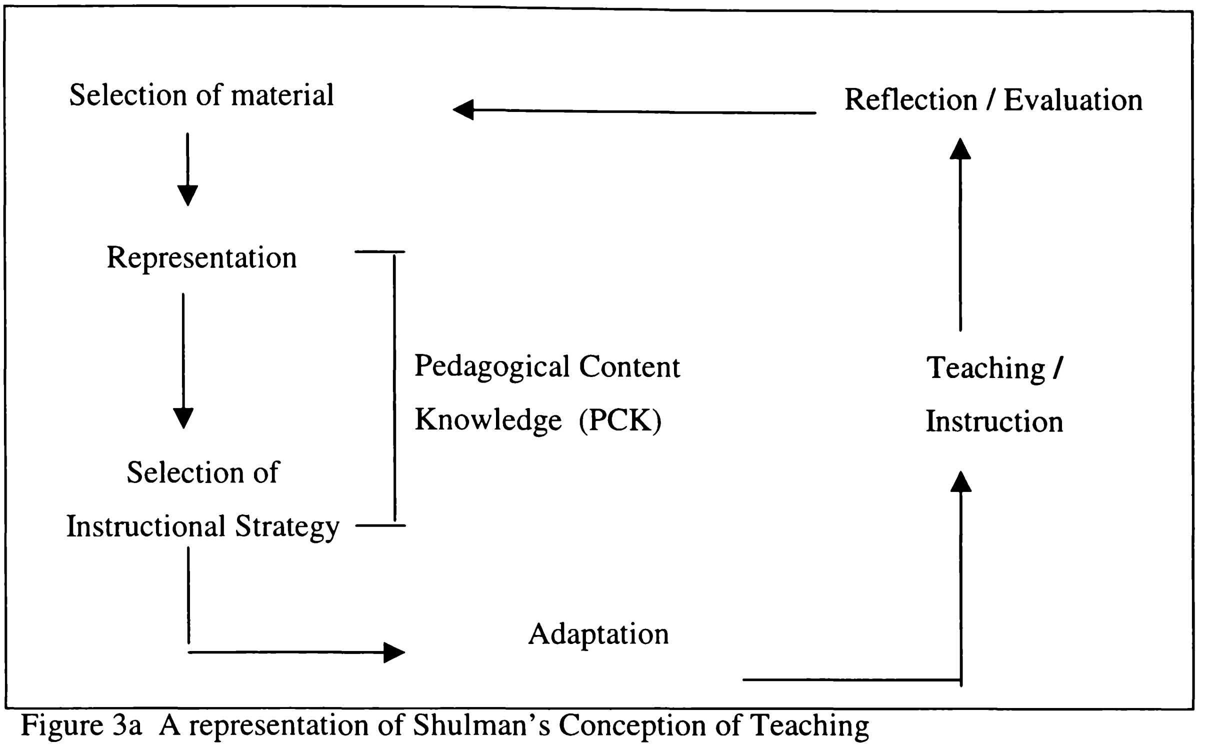

Figure 3a A representation of Shulman's Conception of Teaching

3.3.2.1 Interviews

During the course of study, there were four rounds of interviews (Table 3e). The interviews were scheduled to identify the changes in the views of science learning and teaching, the strategies in planning and conducting science lessons, confidence in teaching science, and the student-teachers' feelings about teaching science in school.

In constructing the interview schedules, the questions were organised under the three aspects of development: professional, personal and social. Under professional development, the questions aimed to identify the student-teachers' views of science teaching from a constructivist view of learning. In addition, how important they regarded the subject in comparison with other subjects and their view of what they thought pupils should learn in science were collected. Under personal development, their confidence to teach, and the feelings associated with being a science teacher at the various phases were compared. Questions concerning social development started to appear in the third interview, by which time the student-teachers had had actual teaching experience. It is from this time onwards that the student-teachers had a school context within which to think about their role as a science teacher.

Table 3e Time Schedule of the Interviews

Phase	Interview No.	Interview Schedule (Appendix No.)	Timing
1	1	A1	At the start of the module N =13
1	2	A2	After the end of the Curriculum Studies module N = 13
2	3	A3	After the teaching practice N =11
3	4	A4	Three months after graduation N = 5
3	5	A5, A6	During and after the implementation of the resource packs N = 5

The interviews were focused to identify themes for comparing the development of the student-teachers and the beginning teachers in the three phases of the study. For professional development, the focus was on finding out the student-teachers' views of teaching science from a constructivist view of learning, and their views of science learning as a subject in primary school: the importance and what pupils should learn. In terms of personal development, the questions aimed to find out their confidence to teach science and their associated feelings. For their social development, the focus was to find out their relationship with their pupils and their relationship with other teachers and the school prinicpal. Although the interview schedules were set, the interviews were semi-structured in that certain themes that seemed to be significant during the interviews were discussed in greater details than others.

The first interview aimed to identify a baseline for comparing the development of the student-teachers in the other phases of the study. In the area of professional development, the prior views as to what pupils should learn in science, and the importance of the subject, as well as the student-teachers' previous knowledge about teaching were collected. In terms of personal development, the influence of the course on their view of science teaching, the influence of previous experience on learning science, and their feelings associated with having to be a science teacher or learning to teach science were identified. The following questions were asked in the interview:

Professional Development

1. What do you think is or are the important things that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?)
2. Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc.?
3. What do you think science is? How would this view of science influence your teaching? What is the role of the teacher in teaching science?
4. With reference to science teaching, what are the steps in your lesson preparation?
5. When you teach science, what are the most common strategies that you would employ? What are the reasons or principles for choosing these strategies?
6. Do you think that pupils have some preconceptions in science before they go to the science lessons? What would you do if you found out that pupils have such preconceptions?

Personal Development

1. Does the present 2PC (2-year Primary Certificate) course have any influence on your science teaching? What are the influences?
2. Can you describe your past experience in learning science? (Have the teachers who have taught you before had any influence on your teaching? What are the influences? OR Does your experience as a student have any influence on your teaching? What are the influences?)
3. How do you feel about having to teach science topics in General Studies?

The second interview elicited how their views had changed in relation to the module, and how they would plan to teach science in their teaching practice. The questions addressed their professional development and focused on: post-module views on what pupils should learn in science and the importance of the science subject, the teaching strategies learnt, and those that they expect they would employ in their teaching practice, and the influence of the module on their teaching. In terms of personal development, their feelings associated with implementing the new strategies in their teaching practice was the theme of the questions. The questions asked were:

Professional Development:
1. What do you think is or are the important things that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?) Have your views changed? If so how and why?
2. Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc.? Have your views changed? If so how and why?
3. With reference to science teaching, what are the steps in your lesson preparation?
4. When you teach science, what are the most common strategies that you would employ? What are the principles in choosing those strategies? (Or What do you remember about the strategies that we have covered in the module? What do you think about their applicability in your situation?)
5. How do you feel about studying the Curriculum Studies module? Has the module had any influence on your science teaching? What are the influences?

Personal Development:
1. How do you view yourself learning to teach science?
2. How do you feel about having to teach science topics with a constructivist view of learning?

Social Development:

What does it mean to you to be a teacher of science?

The third interview, which was conducted after the teaching practice, was designed to find out the student-teachers' views of science teaching, how they saw the importance of science as a subject after having classroom teaching experience, the strategies that they actually employed in their teaching and the influences on their teaching. Their feelings and confidence associated with science teaching were also identified. Starting with this interview, questions that focused on finding out the influence of the school, including the colleagues and the pupils, were included. The following questions were asked in the interviews:

Professional Development:
1. Have your primary concerns about the teaching of science, and your view at what the important things that pupils should learn in their science lessons are changed? If yes, in what way?
2. Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc. ? Have your views changed? If so how and why?

3. How actually did you go about teaching science topics in the teaching practice?
   Discuss: the preparation, the activities you employ, the principles behind them, classroom management, assessing pupils' learning, and if there are any really successful lessons that you remember.

(The above questions will reveal how the student-teachers teach science e.g. the way they use the textbook, if they ask pupils to read about a topic, how they use worksheets and experiments, etc. This will show if the student-teachers take into account pupils' thinking when teaching.)

4. What significant events occurred during the teaching practice (this period) that influenced your practice in teaching and learning science at the primary level?

Personal Development:

1. How do you feel about being a science teacher?
2. How do you view yourself learning to teach science?
3. Has the teaching practice had any influence on your confidence to teach science? What are the influences? How do you feel about having to teach science topics with a constructivist view of learning?

Social Development:

1. How would you describe your relationship with your pupils?
2. How would you describe your relationship with other teachers and the school principal? (How does this compare with the time of student-teaching?)
3. In your view, what does it mean to be a teacher of science?

In the interviews during the beginning teaching phase, the focus was on how their views had changed as they took up a full-time teaching position (if their views about science learning and teaching had changed), how they taught in the lessons, the support that they received from the school, and the preferred forms of support. The following questions were asked:

Professional Development

1. What do you think is or are the important things that pupils should learn in their science lessons?
2. How would you compare science with other subjects like English and mathematics?
3. With reference to science teaching, what are the steps in your lesson preparation?
4. When you teach science, what are some common strategies that you would employ? What are the reasons or principles for choosing these strategies?
5. To what extent were you thinking of a constructivist view of learning during the lesson? Did the curriculum studies module have any influence on your present science teaching? What are the influences?
6. How would you compare the teaching now with your teaching as a student teacher? What are the main differences?
7. What significant events occurred during this period (or what are the factors) that influenced your views in teaching and learning science at primary level? What are the implications on your practice of teaching science?

8. Do you have any suggestions on how to support the teaching of beginning teachers? What support did you receive? What additional support would have been helpful to you?
9. Did you reflect on your teaching? What was it like? What help would you like to enable you to do more?
10. What feedback did you receive? What additional feedback would have been helpful to you?

Personal Development

1. How do you feel about having to teach Science topics in General Studies?
2. How do you perceive your future development in teaching science, in terms of teaching skills and confidence?

Social Development

1. What does it mean to be a science teacher in school? Has your view changed? What is influencing the way you see this?
2. Are you the same sort of (GS) General Studies teacher as other teachers in the school?
3. What do you see as the role of the teacher in students' learning science?

In the interviews during the implementation of the resource pack, the beginning teachers were asked to describe how they had used the materials, the reasons and considerations for their choice, what teaching and learning was like during the implementation, whether other teachers in the school were involved in the implementation, their confidence in science teaching, and how they postulated their directions of science teaching in the future. The following questions were included:

Professional Development

1. How do you feel about the lesson you have just conducted?
2. What were your intentions in the planning and have they been achieved in the lesson?
3. How differently have you taught compared to other science lessons?
4. What are the ways that you have used to stimulate pupils to think?
5. What are the ways that you have helped pupils apply their new ideas?
6. How did you go about finding out pupils' ideas? Having found their ideas what did you do next?
7. What do you think about the pupils' learning in the lesson? Has better learning occurred?

Social Development

Did you discuss with your colleagues or peers the use of the materials in the resource pack? What were the discussions about?

Personal Development

How do you feel about using the materials designed in the package?

In the last interview, after the beginning teachers had completed teaching the topic with the resource pack, the questions were focused to identify their opinions about the resource pack, how they chose the materials, whether they influenced other colleagues in the school, the reactions of their pupils, their confidence to teach science and what their future teaching would be like. The following questions were asked in the interview:

Professional Development
1. Can you describe how you have used the resource pack?
2. What do you think are the strengths and weaknesses of the resource pack?
3. Has the use of the resource pack influenced the way that you look at what is most important in science learning?
4. Has and will the use of the resource pack influence your choice of teaching strategy? What are the influences and why?
5. What are the influencing factors that may affect the implementation of the materials in the resource pack?
6. Do you have any suggestions on how to improve the resource pack or support the teaching of beginning teachers?
7. What is your view of teaching in general? How do you think children learn best? How has your view changed compared with before your graduation?

Personal Development
1. Does the resource pack have any influence on your confidence in science teaching? What are the influences?
2. How would you perceive your future direction in teaching science, in terms of teaching skills and confidence in using the resource pack?

Social Development
1. Did you discuss with your colleagues or peers the use of the materials in the resource pack? What were the discussions about?
2. What were the reactions of the pupils towards the activities suggested in the resource pack? How would these influence your teaching and confidence?

*Other questions were included as arising from the teacher's journals, pupils' work and the questionnaire findings.

The interview schedules were used as a guide only, as each of the participants responded differently, and their responses were further explored. For the first two interviews, they were conducted in the office of the researcher. The interviews after the teaching practice were conducted in the school after the lesson observation. The interviews in the beginning teaching phase were all conducted in the schools and after the lesson observations. Each of the interviews lasted for about one to one and a half hours. The interviews were conducted in Cantonese and were recorded. The interviews were transcribed and translated into English.

3.3.2.2 Lesson Observation

The lesson observations were conducted during the teaching practice and during the beginning teaching. For each participant in the study, one observation was made in the teaching practice period and three others were made during the beginning teaching phase. The focus of the observation was on the extent to which the student-teachers had taught science based on a constructivist view of learning. Each of the lesson observations lasted for one General Studies lesson that ranged from 35 to 40 minutes. The observations were voluntary on the part of the student-teachers and did not contribute to the assessment of the teaching practice. The assessment for the Curriculum Studies module was independent of their performance in the teaching practice. The student-teachers were assessed on their teaching practice by other lecturers and the researcher was not involved in the supervision of the student-teachers who participated in the study. During the observations, field notes were taken and the lessons were audio-taped. As the lessons were conducted in Cantonese, the lessons were translated and transcribed. The observations provided support to the data obtained in the interviews concerning how the participants' views of science teaching were translated into classroom situations.

3.3.2.3 Journals

In order to capture the thoughts of the beginning teachers as they started to teach and as they employed the resource packs, they were invited to write journals to document their thoughts and experiences. The beginning teachers were invited to write about three episodes of teaching within the first three months of their teaching and six lessons during the implementation of the resource packs. The focus of the journals was to find out the extent to which the beginning teachers were teaching science based on a constructivist view of learning and their thoughts and feelings about their teaching. Each of the beginning teachers was given the different guiding questions for writing up the journals during the two time periods. The first set of guidelines (Appendix B1) for the journals written three months after beginning teaching was:

> Describe three General Studies lessons that you were most impressed with. For each of them describe:
>
> i. the lesson content, how you prepared for the lesson, what your considerations and teaching method were;
> ii. what happened during the lesson, what activities were conducted and how the pupils responded;
> iii. what your feelings were after the lesson.

The second set of guidelines for the journals (Appendix B2) written during the implementation of the resource pack was:

> Describe six lessons during which you employed the materials or strategies suggested in the resource pack. For each of them describe:
>
> i. the materials or content that were employed;
> ii. what happened in the lesson, what activities were conducted and what the pupils' responses and questions were;
> iii. how you responded to the pupils' questions;
> iv. if you think the activities stimulated the pupils to think;
> v. whether the lesson was successful or not, and what the reason was;
> vi. if you teach this topic again, what you will do;
> vii. what support you need.

The findings from the journals were to support and add to those from the interviews and the lesson observations.

Apart from the interviews, lesson observations and journals, data were also collected in the module sessions. Summaries of the discussion records of the student-teachers in the group activities were also taken by the researcher as a source of data.

3.3.3 Quantitative measures

The quantitative data collection was conducted during the three phases of the study as summarized in Table 3f. Before the commencement of the module, three questionnaires were distributed to the student teachers. The first one was a student teacher background questionnaire (Appendix C1). The items were adapted from a study by De Latt and Watters (1995) which revealed variables that might possibly influence the scores in the Science Teaching Efficacy Beliefs. In addition, reference was also made to a questionnaire on teacher education students (Su, 1993).

Table 3f Administration of the questionnaires for the quantitative part of the study

Time	Questionnaire Items
Before the commencement of the Curriculum Studies module N = 39	1. The student teacher background (Appendix C1) 2. The Science Teacher Efficacy Beliefs questionnaire (Appendix C2) 3. The science teaching questionnaire (Appendix C3)
After the Curriculum Studies module N = 36	The science teaching questionnaire (Appendix C3)
After the teaching practice N =20	1. The post-teaching practice questionnaire (Appendix C4) 2. The Science Teacher Efficacy Beliefs questionnaire (Appendix C2)
At the beginning teaching phase N= 5	1. The beginning teaching questionnaire (Appendix C5) 2. The Science Teacher Efficacy Beliefs questionnaire (Appendix C2)

The second questionnaire was the Science Teaching Efficacy Beliefs instrument (Appendix C2). This questionnaire was administered before the module and after the teaching practice. The Science Teaching Efficacy Beliefs instrument (Riggs and Enochs, 1990) was adapted to reflect the local context, and was translated into Chinese. In order to identify if there were changes in the Science Teaching Efficacy Beliefs among the student-teachers in the teacher education programme, the instrument was administered at two points. The first time was before they took the Curriculum Studies module. This set the basis for comparison. The second time was after the teaching practice, just before they graduated in around June, which was the last month of the semester. The comparison showed the influence of the module and the teaching practice on their confidence to teach science. This captured the perception of the novices after they started teaching, and the data supplemented the information obtained in the qualitative part of the study. Moreover, this questionnaire was also distributed at the end of the beginning teaching phase to find out the confidence of the beginning teachers in teaching science.

In the science teaching questionnaire (Appendix C3) which was distributed after the teaching practice, there were three main questions, which included:

- the frequency of the teaching activities adopted in science lessons;
- the extent to which they agreed with a number of statements about science teaching;
- a situation question that described a number of possible actions after having found out that the pupils could not understand concepts about the properties of air:

> You have taught a topic on air to a class of primary 4 pupils. At the end of the topic, you find out that your pupils think that:
> air is weightless
> water droplets that condense on the surface of a can of soft drink come from the inside of the can.
> What would you do in the next lesson?

The first two questions were rated on a five point Likert scale and a larger value represented higher frequency of stronger agreement. In the third question, the student-teachers were asked to rank order the ten possible actions.

In the post-teaching practice questionnaire (Appendix C4) distributed after the teaching practice, the student-teachers were also invited to rate the degree of difficulty they experienced for six tasks:

- understanding pupils' preconceptions
- having sufficient science academic knowledge
- conducting activities
- conducting practical activities
- classroom management
- stimulating pupils to think.

The ratings were made from a 0, 1 to 5 scale with 0 meaning no difficulty, 1 indicating little difficulty, and 5 indicating extreme difficulty.

The beginning teaching questionnaire (Appendix C5) distributed at the end of the beginning teaching phase included the questions about the degree of difficulty of the various tasks, the confidence of the beginning teachers in teaching in general, and in teaching science topics as compared with other subjects such as mathematics and Chinese, as well as with other topics in the General Studies curriculum.

3.4 Data analysis

This section describes how the data were analysed and how the coding represented the sources of the qualitative data.

3.4.1 Analyzing the data

The aim of the data analysis was to identify the social reality that the participants had constructed. Themes and categories were developed as the researcher read through the transcriptions and the journals. The findings in the journals and the lesson observation transcriptions were analysed in much the same way as the interview transcriptions. The data were coded according to the themes or categories. A list of themes emerged after the coding process. This process was conducted such that analytical categorization of data was achieved. In each of the interviews, the number of occurrences of each of the themes was identified. Moreover, the total number of occurrences across the interviews with different participants was summarized. Finally, the similarities and differences across the cases were examined in order to identify the patterns, and draw conclusions on the study.

The method of analysis in the present study resembled that of a summary by Neuman (1997) who related Spradley's domain analysis as involving six steps:

(1) rereading data notes full of details
(2) mentally repackaging details into organizing ideas
(3) constructing new ideas from notes on the subjective meanings or from the researcher's organizing ideas,
(4) looking for relationships among ideas and putting them into sets on the basis of logical similarity,

(5) organizing them into larger groups by comparing and contrasting the sets of ideas,

(6) reorganizing and linking the groups together with broader integrating themes. (Neuman, 1997, p.432)

This is a process that starts from specifics in the data and builds up finally into an overall set of logical relationships.

There were three phases in the study and, as in other qualitative studies (Miles and Huberman, 1994), the data collected in each of the phases were analysed with an aim to guide the next move in the field. Miles and Huberman (1994) suggested that the purpose of the analysis of the qualitative data is to compare across data and in deciding or choosing what to report, analytical choices are made continually. They further elaborated that while meanings about people's actions were generated through observations and interviews, this information would guide the researcher's subsequent move. This is comparable with the process of analysis in the present study. When the observations and interviews in the first two phases reflected the learning experiences of the student-teachers and their needs as beginning teachers, the intervention in the third stage was designed based on these results and the analysis. In the present study, the data in earlier phases informed the intervention in subsequent ones, and generalizations were made from the interviews, classroom observations or data from the journals. For example, the data obtained at the early beginning teaching phase was applied to inform the design of the resource packs. The last stage of the analysis involved an examination of the findings or generalizations from a sociocultural view of learning.

In analysing the lessons observation records which included field notes and transcriptions of the lessons, the researcher drew up a list of teaching actions that were congruent with the constructivist view of learning. The list is drawn based on a teacher development project that helped teachers to teach science from a constructivist view of learning (Bell, 1993). The actions were chosen on the basis that they characterized science teaching from a constructivist view of learning and that they differed significantly from "typical" science lessons in Hong Kong as follows:

i. Presenting questions for pupils
ii. Inviting pupils to ask questions
iii. Asking pupils to predict results of practical activities
iv. Illustrating by using a range of examples
v. Illustrating by using practical activities
vi. Relating new ideas with previous concepts
vii. Using newly learnt ideas in new situations
viii. Pupil initiated activity
ix. Clarifying pupils' ideas by using other examples

These were also actions that were observable during the lesson observations. The non-observable actions for a lesson, such as lesson preparation, were not included in the checklist. The interviews and the journals provided data to supplement this area. The planning and other teacher actions, such as eliciting pupils' preconceptions that might not be observable in a lesson, were described and analysed separately in the interviews and the journals. The number of occurrences in each of the lessons observed was counted and the total number of occurrences in all the lessons observed was also summarized.

The transcriptions, the field notes from the lesson observations, and the journals were analysed and compared against the checklist. Each of the cases was analysed, and actions that agreed with those in the checklist were counted and summarized. The counts were made if a particular action was found in the observation, and then it was taken as an occurrence or match. Thus, the count represented the frequency of the actions during the lesson observed, and the quality of the actions was illustrated with quotations from the accounts.

The quantitative data in the questionnaires were analysed by the SPSS software package. The mean values for each of the items were obtained. The findings from the value before the commencement of the module and after the teaching practice period were compared by using both a t-test and a sign test. In each of the measurements, the mean value and sum of the items that contributed to Personal Science Teaching Efficacy Beliefs, as well as the mean and sum of the items that contributed to Outcome Expectancy Beliefs, were calculated. These values served to indicate the confidence of the novice teachers in teaching science and in effecting positive learning outcomes among the pupils.

3.4.2 The coding of the transcriptions, lesson observations, field notes and journals

The 13 student teachers who participated in the first phase of the study and were interviewed before the study of the module were each represented by a letter from A to M. The coding of the data consisted of the letter that represented the participant, the second alphabet letter (e.g.i) represented that the data was obtained from interviews and was then followed by a number that represented the interview. The number "1" represented an interview before the Curriculum Studies module, "2" represented an interview after the Curriculum Studies module, "3" represented an interview during the teaching practice. For example, "Ai1" refers to participant A in the first interview. Among the thirteen student-teachers who were involved in the first round of interviews, eleven had a chance to teach a science topic in their teaching practice. Besides interview data which were coded in the same way as in the previous round, the lesson observation data were also coded.

A similar principle was adopted in coding the data from the lesson observation, i.e. the first alphabet (e.g. D) represented the teacher, the second alphabet "o" represented lesson observation, (or it could also be "n", meaning field notes made during the lesson observation), the last digit (e.g. 6) was the grade level of the pupils. "Do 6" was therefore a piece of transcription of the lesson observation and "Don6" was a piece of data from the field notes of the lesson observation of teacher D, who was teaching a class of primary 6 pupils.

The discussions of the student-teachers during the Curriculum Studies module were summarized and coded as "discussion notes". These were conclusions that the student-teachers wrote during the group discussions in the module sessions. These were originally written in Chinese and were translated.

The eleven student-teachers who participated in the teaching practice phase of the study had all graduated from the programme, and among them three did not succeed in finding a teaching job while three others taught in special needs schools. The remaining five subjects who participated in the final phase of the study were teachers B, I, L ,E and D. The representations of the teachers were the same as those used in the previous phases of the study. Teachers B and I were teaching in the same primary school but they were teaching different levels for the subject of General Studies.

For the coding of the interview data at the beginning teaching phase, the first letter represented the teacher, the second letter "b" represented beginning teaching, the third letter "i" meant interview, and the last digit "1" meant that it was the first interview in the beginning teaching phase. The number "2" means that the interview was made during the implementation of the resource pack and number "3" means that the interview was near or at the end of the implementation of the resource pack. Thus, "Lbi1" refers to the first interview with the beginning teacher L.

The lesson observation data collected during the beginning teaching phase were coded in a similar way. The first letter (e.g. B) represented the teacher, the second letter "b" represented the beginning teaching phase, the third letter "o" represented observation transcription, and the last digit (e.g. 2) meant the sequence of observation. "Bbo2" was a transcription from the second lesson observed at the beginning teaching phase for teacher B. In situations where there was an additional letter "n", which represented the researcher's notes. "Bbon3" therefore came from the researcher's notes as the 3rd lesson observed for teacher B.

For the coding of the data from the journals written by the beginning teachers at the beginning teaching phase, the first letter represented the teacher, the second letter "j" represented journal and the last number "1" meant that it was written before the use of the resource pack, whereas the number "2" meant that it was written after the use of the resource pack. Hence, "Ij2" was taken from the journal of teacher I written after the use of the resource pack at the beginning teaching phase.

3.5 Interventions that support teacher development

There were three main phases in the study and the interventions were designed in accordance to the needs of the student-teachers or the beginning teachers at each specific stage. The strategies aimed to facilitate the development of the student-teachers and the beginning teachers. Moreover, the design of the strategies was made in accordance with the recommendation of the literature about how teacher educators should teach, as summarized in Chapter 2 (Section 2.4.2). During the first phase, the student-teachers began to learn about teaching science, and a Curriculum Studies module was designed to facilitate their early development. During the teaching practice, there were support group meetings, visits and observations. Having identified the needs of the novices at the beginning teaching phase, two resource packs were designed. The following sub-sections describe in greater detail the Curriculum Studies module and introduce the support provided during the teaching practice, whereas the design of the resource packs will be elaborated in greater detail in Chapter 7, together with an analysis of the needs of the beginning teachers.

3.5.1 The Curriculum Studies module

The Curriculum Studies module was designed such that (i) student-teachers were more aware of pupils' preconceptions in science, (ii) student-teachers were aware of the various approaches to science teaching, and (iii) professional development of the student-teachers was encouraged through enhancing their capability in teaching science from a constructivist view of learning. Table 3g depicts the outline of the module. A total of 39 student-teachers took the module and each of the sessions lasted for 2 hours. The module was delivered in cooperation with another lecturer who was teaching a parallel group. There were agreements on the content of the module between the two groups but the sequence of the topics varied. The assessments of the two groups were also the same.

Table 3g The Teaching Schedule for the Curriculum Studies module for the Non-science electives

Session	Content
1	1. Ways to find out children's preconceptions in science 2. Stimulating awareness of the influence of previous (science) education experience on teaching
2	Different approaches to science teaching
3	Different approaches to science teaching Ways to develop children's ideas and carry out follow-up investigations
4	Different approaches to science teaching
5	Planning and teaching science – example topic "air"
6	1. The Nature of Science 2. Aims and content of science education 3. Science, Technology and Society
7	1. Science curricula in different parts of the world 2. Science-related topics in the Hong Kong Primary curriculum 3. Teaching schemes or teaching plans
8	Microteaching
9	Microteaching
10	Microteaching
11	Microteaching
12	Test

3.5.1.1 The rationale behind the Curriculum Studies module for the non-science elective

As the module was offered in the second year of the 2-year programme, the student-teachers had already had some experience in teaching practice, and had studied in other modules about constructing concept maps, and teaching activities like brainstorming, group work and reflection. A 45-hour module was also offered in the first year to strengthen the science content knowledge of the student-teachers. The present Curriculum Studies module (Appendix D) was offered in the second year as an option for the student-teachers who felt the need to further their understanding of science teaching after their first teaching practice.

Instead of separating academic studies from curriculum studies, academic knowledge was presented in the light of how it related to teaching. In the module, the student-teachers learnt to relate their teaching with pupils' preconceptions of certain topics. Examples of selection and representation of content material were discussed. While a number of science teaching approaches were introduced, the module advocated science teaching based on a constructivist view of learning.

There were two parallel teaching strands in the module. As the student-teachers were learning to teach young children from a constructivist view of learning, they were asked to consider learning for themselves as a learner. In the former strand, there was an introduction to children's ideas of science, an examplary teaching unit on the topic of "air", suggestions for possible activities that elicit pupils' ideas or help them to change their conceptions, and activities that allow pupils to use new ideas. In the latter strand, the student-teachers shared their previous learning experiences, and experienced the various teaching approaches, namely, the discovery approach, the process approach, the experiential approach, and teaching science based on a constructivist view of learning. In this process, the student-teachers had to consider their role as learners and the role of the teacher as they adopted the different approaches. After having an experience of the different teaching approaches, an analysis of the topic of air was introduced as an example such that the student-teachers could better understand the considerations in science teaching based on a constructivist view of learning. Finally, the aims of the curriculum and the nature of science were introduced, and the last part of the module included opportunities for the student-teachers to take part in micro-teaching.

3.5.1.2 The Content of the Sessions in the Module

This section includes a more detailed description of the sessions in the module.

Session 1

This session introduced to the student-teachers a number of activities for finding out children's preconceptions in science (Bell, 1993a):

- Interview-about-instances
- Surveys
- Viewfinder
- Card sorting

Selected activites were then conducted in order to increase student-teachers' awareness of the influence of their previous educational experiences on their science teaching. These activities were suggested by Schratz (1993). The first activity conducted with this aim was the "magnifying glass". This involved asking the student-teachers to write down their own feelings, problems or expectations in their science teaching on a piece of paper. After each individual had finished, the group shared and discussed their experiences. The second activity was to ask the student-teachers to draw a concept map of what they thought science teaching was. Finally, the student-teachers were also engaged in an activity in which they wrote down their feelings, and shared how science learning was for them in their secondary or primary schools.

Sessions 2 to 7

In these sessions, a number of approaches to science teaching were introduced. A representation of seeing the approaches from a positivist to a constructivist end, as suggested by Barker (1991), was used as an overview of the various teaching approaches. As most of the student-teachers were familiar with a transmissive teaching approach, the experience in the module covered the four other approaches: guided discovery approach, process approach, experiential approach and teaching science based on a constructivist view of learning, in order from a positivist to a constructivist view of science learning. In the introduction to each of the approaches, the student-teachers participated in the activities as a learner. Then, they discussed their experiences as a learner and the role of the teacher in the process. Moreover, they compared the experiences in the four approaches, and discussed the implications of the implementation of the various teaching approaches.

In order to provide the student-teachers with a concrete example of what science teaching from a constructivist view of learning meant, a teaching schedule outlining the details of the topic sequence and the activities on the topic of air were discussed in the sessions (Appendix D). The example included possible preconceptions that children may have as shown in the literature, the sequence of the topics, ways to help change pupils' ideas, and the suggested activities. With this worked example, the student-teachers could better visualise what science teaching based on a constructivist view of learning is like.

The sessions also included an introduction to a number of ways that the teacher may help children to develop their ideas; for example through acknowledging ideas, questioning and differentiating ideas. Furthermore, the discussion moved on to ways to represent the concepts learnt by using:

- Venn diagrams
- representation of concepts in diagrams (Baird and Northfield, 1987)
- concept maps (comparing pre- and post-teaching concept maps).

The researcher also analysed with the student-teachers ways to promote and use pupils' questions. Strategies that help pupils to reflect upon their learning and teaching were adopted in the module, such as:

- post-box activity (Bell, 1993a)
- learning checklist (Baird and Northfield, 1987)

Apart from these, ways to conduct follow-up investigations and experiments were included in the discussions.

Sessions 8 to 11

Each student-teacher prepared a science lesson and chose 15 minutes out of it to share with other student-teachers in the class. Before teaching the lesson to other student-teachers, the student-teacher prepared the lesson plan, the activities and the materials e.g. teaching aids, worksheets for the whole science lesson. After each of the try-out teaching sessions, the researcher conducted a discussion with them to help them to reflect on their own teaching. In addition, the researcher and other student-teachers in the group shared their feedback about the trial teaching. However, since the micro-teaching was part of the assessment, data was not collected in these sessions.

3.5.2 Support in the teaching practice and in beginning teaching

During the teaching practice and in the beginning teaching phase, the researcher had a number of discussions with the student-teachers who participated in the study. In the teaching practice, the discussions were mostly on a one-to-one basis, in which the student-teachers called on the researcher at the office, or spoke over the telephone. The discussions were about problems or implementations of different science teaching strategies in their science classes. Moreover, two workshops that prepared the student-teachers for teaching practice were held just before the commencement of the teaching practice. In the workshops, the student-teachers who were going to teach the same topic grouped together and shared with each other their teaching plans, teaching ideas and resources.

During the beginning teaching phase, and after having identified the needs of the beginning teachers, the researcher provided each of the participants in the study with a resource pack, and a workshop was held to introduce to the beginning teachers the ideas and contents of the packs. The first form of support was provided through the design of the resource packs on the topics of "Heat" for primary two level (Appendix E; Cheng, 1999) and "The Body" on primary four level. While the main purpose of the resource packs were to help the beginning teachers to teach science based on a constructivist view of learning, the design was made after having interviewed the beginning teachers. Hence, their concerns about the lack of time for lesson preparation and the need for teaching resources were taken into consideration as the materials were chosen. The following are the purposes of the resource packs:

- to allow the beginning teachers to re-think the topic sequence that facilitates pupils' conceptual development;
- to provide information about children's preconceptions;
- to include activities that find out pupils' preconceptions;
- to have activities that stimulate pupils to think and discuss the topic;
- to let pupils apply newly learnt ideas in new contexts.

The resource packs included worksheets for pupils, notes for teachers, transparencies and all the necessary stationary and materials for conducting the practical activities, for example, large pieces of paper, felt pens, plastic bottles fitted with drinking straw, plastic filtering funnels and filter paper.

The second form of support was provided through the introductory workshop, which was an opportunity for the beginning teachers to:

- share with the teacher educator and with each other about their school and classroom experiences;
- try out the activities suggested in the resource packs;
- discuss the results of the activities;
- discuss how the activities may be implemented in their classroom situation;
- discuss how the activities relate to the constructivist view of learning;
- raise questions about the resource packs;
- share with each other their teaching experience in the school.

These provided an opportunity for the beginning teachers to share their classroom situations, their problems, and concerns and to reflect on their own teaching. The feedback provided by the researcher and other participants in the workshop also provided personal support. As the beginning teachers had seen each other attempting to work with the activities, this provided a form of social support. They knew that they would not be alone in the endeavor and could reconstruct among themselves what it meant to be a science teacher. They knew that these were common shared values and felt that the task was meaningful.

In addition, support to the beginning teachers was provided through telephone conversations. These one-to-one conversations with the researcher supported their development as the researcher:

- provided encouragement to the beginning teachers;

- provided advice about the use of the materials and the conduction of the activities suggested in the resource packs;
- provided feedback based on their descriptions of the teaching;
- stimulated the beginning teachers to reflect on their teaching and identify other possible alternatives in their classroom context;
- clarified the meaning and the purpose of the activities;
- elaborated on the background of the activities and the design of the resource packs.

Based on a sociocultural view of learning, the resource packs and the opportunities for interactions carried special meanings. The resource packs may be regarded as the mediational means that facilitate the socialization of the beginning teachers into the culture of science teaching based on a constructivist view of learning. The workshops and the telephone conversations were support offered in the form of interpersonal interactions, which may be regarded as mediated actions. A fuller description of the resource packs is provided in Chapter 7 (Section 7.5).

3.6 Ethical considerations

A number of ethical considerations were made in the present study including:

- informed consent;
- privacy;
- anonymity;
- confidentiality.

Before the commencement of the research, the study had received the approval of the University ethics committee. Moreover, it was necessary to obtain the consent and cooperation of participants in the study prior to the beginning of the study (Cohen and Manion, 1994). Consent was sought from the participants at various stages of the study. Before the commencement of the study, the purpose of the questionnaire and the use of the data were explained to the participants. The front page of the questionnaire contained a consent form explaining to the respondents the purpose of the study and the confidentiality of the data obtained. Before the first interview, the researcher explained the process of the study, including the number and the approximate timing of the interviews and the classroom observation sessions, to the respondent. In arranging the interviews and classroom observations, the researcher first made telephone contact with the respondents. The date and time of the interviews and the classroom observations were agreed between the respondent and the researcher. Prior to the classroom observations in schools, the consent of the school principals was also obtained. Access to the teachers and the pupils was negogiated with the school principals in the third phase of the study. By informing the participants of the purpose of, and their involvement in the data collection stages, their consent represented an informed decision. The researcher was aware that the participants had the right to decline at any time. The participants could indicate whether they were willing to participate in the study at various points: initially during the administration of the questionnaire, prior to the interviews, and prior to the lesson observations.

In order to ensure anonymity and privacy, the student-teachers entered their student numbers and not their names on the questionnaires, and in the qualitative part of the study, each of the student-teachers or beginning teachers was represented by a code. The respondents were assured that the data would be used only for the purpose of this study and would be quoted anonymously. Although the researcher, as a staff member of the Institute, could match the student number and the names, there was no attempt to relate them in the analysis. In writing up the thesis, the privacy of the participants in the study was protected by their remaining anonymous throughout the process of data collection, analysis and reporting of the study. Neither the names of the schools nor the individual participants were mentioned in the thesis or were made known to the reader. If the data is to be used in future for a different purpose, prior consent from the respondents would be sought.

A number of measures were taken to make the identity of the participants and the data confidential in the study. Both the quantitative and the qualitative data were locked away and were kept confidential. They were not released to other lecturers involved in the programme. The interview tapes were translated and transcribed by the researcher. Data collected in the form of field notes, recordings from module sessions, recordings from discussion sessions and lesson observations were also handled by the researcher.

As suggested by Cohen and Manion (1994), social studies research should not cause pain or indignity to the participants, self-esteem should not be undermined, nor confidences betrayed. The researcher was aware of the principle and also realised that the lesson observations may cause feelings of stress for the student-teachers and the beginning teachers. The participants were assured that the observation would not have any bearing on their assessment. Throughout the project, the researcher monitored the possible stress inflicted on the participants.

3.7 Summary

In order to understand teacher development, the present study included three phases, namely, the first phase within the curriculum studies module, the second during the teaching practice period, and the third during the beginning teaching phase. The study adopted an interpretive approach. This approach was found to match closely with the purpose and the nature of this study which adopted a sociocultural view of learning to analyse teacher development. Although qualitative methods of data collection identified with the interpretive approach, a mix of both qualitative and quantitative methods was adopted such that the two types of data could support each other.

In order to identify the development of the student-teachers and the beginning teachers at the various phases, data collection strategies such as interviews, journals, classroom observations and questionnaires were employed. These provided data to portray the professional, personal and social development of the student-teachers or the beginning teachers. The intervention strategies included support in the form of the Curriculum Studies module in the first phase, workshops in the teaching practice period and resource packs with other forms of support at the beginning teaching phase. The inventions were drawn to enhance the development of the novices such that they may teach science based on a constructivist view of learning. Finally, the chapter concludes with how the researcher has ensured that the study was conducted with ethical considerations including principles of informed consent, privacy, confidentiality and anonymity.

Chapter 4

Student teachers' prior views about science teaching and learning

4.1 Introduction

The findings reported in this chapter provide a basis for comparing the changes in the teaching and development of the student-teachers in the process of learning to teach. This chapter documents the views about science teaching and learning held by the student teachers before they took the Curriculum Studies Module. The findings were collected from the interviews of the 13 student-teachers (interview schedule in Appendix A1).

The findings are reported under four main categories, three of which are to be compared at the later stages of the study. The three main themes that are comparable in later stages are namely, the student-teachers' views about the importance of science learning, their views about science teaching, and their feelings about teaching science. The fourth theme describes the previous science learning experiences of the student-teachers which serves as a basis for understanding the learning processes of the student-teachers.

4.2 Views of science learning - the importance of learning science content in the primary curriculum

The student-teachers were asked to describe what they think is important for pupils to learn in science, and to compare the relative importance of the place of the science curriculum with other subjects at primary level. The importance of learning the content knowledge was shared by most of them, as eight of the thirteen student-teachers mentioned this as an important aspect (Table 4a). The student-teachers regarded the study of science at the primary level as a foundation for future study and that the learning of academic knowledge in the subject became the main concern, for example:

> The basic concepts, they (the pupils) will then learn a lot of other things later... Without a good foundation, they are not sure whether they have learnt the concepts before or not... It is a foundation for future learning. (Bi1) (see Chapter 3 section 3.4.2 for a description of the coding)

Table 4a Student-teachers' views expressed in the interviews on the importance of learning science content in the primary curriculum
(N=13)

Importance of Learning Science Content in the Primary Curriculum (What do you think is or are the most important things that pupils should learn in their science lessons? What are your primary concerns about the teaching of science?)	**Occurrences[1] in the interview data**
To learn science knowledge/ basic concepts for lower primary/ build up a foundation for future learning	8
To learn something that is related to daily life experience	5
To learn how to do experiments	1
To develop an ability to hypothesize; an attitude of finding out; an ability to think	5
To develop self learning	1
To develop an interest in science	1
The relative importance of science as compared with other subjects (Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc.?)	
The most important subject	1
One other subject was more important	4
Two other subjects were more important	5
Three other subjects were more important	1
All the subjects were of equal importance	2

The need for including content relevant to the experience of the pupils was raised. Five of the student-teachers suggested that the content at the primary level should be related to the daily life experiences of the pupils, for example:

> Pupils would like to learn more about their daily lives, relevant to their experience. Content about the earth and the moon are too difficult for the children and they may not want to learn these.

[1] The number of occurrences in all the tables of summary of interview results represents the total number of times that a certain theme was mentioned in all the interviews. However, this number arises from a detailed analysis of individual interviews. See also Chapter 3, section 3.4.1.

(Hi1)

The content was only part of what had to be learnt, another concern raised (by five of the thirteen student-teachers) was that pupils should develop the ability to think, hypothesize and find out by themselves, for example:

> They should be able to think by themselves and not necessarily following the way of the teacher. Children have a special way of thinking (which is) quite different from adults. It is important that they can use their own way of thinking. (Fi1)

This quotation illustrates that these five student-teachers were able to realize that pupils have different ways of thinking, which is different from the emphasis on the content knowledge. Comparatively, only one student-teacher realised the importance of the ability for self-learning and developing in pupils an interest in the subject:

> They (the pupils) should learn how to learn by themselves, not only being told by the teacher. They should have the drive to find out... They should be able to find out more by themselves. (Gi1)

On comparing the importance of science learning with other subjects at the primary level, science did not seem to be a very important area, the position for science learning was quite low for the six respondents who put it in the third or fourth place. Despite this, two respondents have suggested that all the subjects should be equally important, while five respondents regarded science content as being more important and put it in the first or second place among the subjects (Table 4a). The student-teachers who felt science to be of relatively low importance were like most of the parents and teachers in Hong Kong who regarded the languages (Chinese and English) and mathematics as the more, if not the most, important subjects. This is because the assessment results of these subjects contribute to the secondary places allocation at primary five. However, the assessment result for science or General Studies is not counted.

To summarize the views of science learning of the student-teachers, these responses suggested that they shared much concern about learning the content knowledge of science, although a small proportion (5)[2] of them realized the importance of developing the pupils' ability to think, or self learning, as they teach science. They did not place much importance on science learning as compared with other subjects.

4.3 Views of science teaching

This section describes the student-teachers' view of science teaching before they studied the Curriculum Studies module. In order to find out about their views of science teaching, the following questions were raised in the interview:

- What do you think science is? How would this view of science influence your teaching? What is the role of the teacher in teaching science?
- With reference to science teaching, what are the steps in your lesson preparation?

4.3.1 Concerns and strategies during lesson preparation

Consistent with the importance that the student teachers gave to the learning of science content knowledge in the previous section, they showed great concern with the preparation of content for teaching. Concerns about content were mentioned 16 times in the interviews (Table 4b), for example:

> I have to clarify my own concept of the topic. There are times that I was quite confused. (Ii1)

This concern was expressed in different ways: reading up, preparing for pupils' questions, clarifying their own concepts. These student-teachers shared an anxiety about the science content to be taught.

[2] The number in brackets represents the number of student-teacher(s) mentioning this in the interviews.

Table 4b Concerns and strategies in preparing for science lessons (N=13)

Area	**Lesson preparation**	**Occurrences in the interview data**
Content	Read up the content (from other sources)	7
	Read teachers' guide (included in the textbook)	2
	Digest content and teach (based on the textbook)	1
	Understand the topic (based on the textbook)	1
	Clarify own concepts (based on the textbook)	1
	Find out main concepts	2
	Prepare for pupils' questions	1
	Relate content to daily life experience	1
Pupils	Find out pupils' preconceptions	1
	Find ways to impress pupils	1
Teaching activities	Design activities	3
	Design practical activities	5
	Find materials/ teaching aids	4
	Try out practical activities	1
	Design worksheets/ questions	1
Discussions and consultation	Consult supervising teachers / lecturers	1
	Discuss with peers	1

The second area in which the student-teachers shared much concern was in conducting practical activities, as five mentioned this in the interviews. In preparing for science lessons, besides preparing for the content, they designed activities, practical activities, worksheets, and found the appropriate resources. Only two of the respondents mentioned that they would consult with their peers or the supervising teachers in their preparation. It is also interesting to note that one of the respondents mentioned that he would find out pupils' preconceptions in his lesson preparation.

> I will start with questions; these are direct methods for finding out how much pupils know. Then, I will use practical activities if applicable, if not, I may ask them to observe the things around them. I will also ask the pupils to find out the relation or the differences. (Ci1)

This student-teacher was concerned about what pupils knew before the lesson, instead of whether they had the "right" answer or not. Lesson preparation was perceived to be a lonely activity as only two of them mentioned discussion with others during this exercise. The predominant concerns in preparing for science lessons were the science content and conducting practical activities. There was little awareness of pupils' preconceptions.

4.3.2 Views about using various teaching strategies and activities in teaching science

The student-teachers were asked the following questions in the interview:

> When you teach science, what are the most common strategies that you would employ? What are the reasons or principles for choosing these strategies?

When the respondents were asked this question, most of them (10 out of 13) equated the teaching of science with doing practical activities or performing demonstrations (2) (Table 4c), for example:

> I will perform some demonstrations for the pupils, then explain the concepts to them through the results. (Ei1)

Few (4) considered discussion or other activities (e.g. games) in science lessons. One of the student-teachers described how he would include games in lessons:

> Provide some worksheets, perform some demonstrations, and let them (the pupils) listen to some audio tapes. They would then answer some questions or complete a worksheet. Sometimes, I would design some matching games for the pupils. (Fi1)

Table 4c Teaching activities/ approach adopted by student-teachers in science lessons
(N=13)

Teaching activities/ approach to be adopted (When you teach science, what are the most common strategies that you would employ?)	**Occurrences in the interview data**
Practical activities	10
Demonstration	2
Discussion	4
Games/ other activities	2
Using analogies	1
Teach in a similar way as Chinese/ mathematics	1
Discovery Approach	1
The reasons for selecting the teaching activities or approaches (What are the reasons or principles for choosing these strategies?)	
To let pupils experience the process	1
To relate to current issues	1
To engage pupils in thinking	2
To let pupils know what was happening	1
To matching activities with teaching objectives	1
Not to teach too much in-depth knowledge	1

There is confusion about which approach to adopt in science lessons, as student-teacher A named the discovery approach but had also suggested that the teaching of science was similar to that of teaching Chinese and mathematics:

> I also think that pupils can have a deeper impression[3] of the topic by using the discovery approach. However, I do not have much confidence in this. I doubt if pupils could be very attentive or concentrate on doing a certain task. In my teaching practice I know that this may not be the case. I would then perform some demonstrations and give them the facts for science. Then they can absorb the content. I would then consolidate their learning. It would be quite similar to teaching Chinese and mathematics. (Ai1)

In this response, the student-teacher appeared to have a confused understanding of the discovery approach and how it relates to pupils' learning. Due to practical

3 The literal translation for the word is impression, however, it means having a strong impact on the pupils.

constraints in the teaching practice, he chose to have a transmission approach by "giving" pupils the facts and knowledge. The teaching of science topics was not different from teaching other subjects. The findings suggest that science teaching was mostly equated to conducting practical activities. The rationale for choosing the activities or the teaching approaches was mainly based on teaching concerns like matching the activities with the teaching objectives, making pupils know what is happening, letting the pupils experience the process, and relating the content with current issues. For example:

> When doing practical activities, be aware if there are current news items or issues that are related to the topic. As pupils are aware of these, they will know that these really happen in life and are not just introduced by me in the lesson. (Di1)

Unlike the above responses which show that the student-teachers did not have clear ideas about teaching science, two of the respondents mentioned that the approach or activities were chosen to engage pupils in thinking. For example:

> I would stimulate them (the pupils) to think through the use of questions. In answering my questions, they can find out the fact. Either the pupils work on practical activities or I would demonstrate. They then find out the conclusion. They learn through the process and the conclusion. (Mi1)

Although the student-teachers described the teaching activities and approaches to be adopted in their science lessons, not all of them were able to provide a reason for selecting such approaches. This is the reason why the occurrences in the second part of Table 4c are lower than the number of total respondents. It appears that the student-teachers did not have a clear concept about science teaching. Science did not appear to be an important learning area. The concerns of the student-teachers were mostly related to the science content and the practical activities.

4.4 The previous learning experiences

The prior science learning experiences of the student-teachers may influence their subsequent learning in the teacher education programme and their teaching in the classroom. The student-teachers were asked to start their description with the most recent experience of learning science in the teacher education programme (section 4.4.1) and then about learning science in their primary and secondary education (section 4.4.2).

4.4.1 Learning experiences in the teacher education programme

To obtain the student-teachers' perceptions of the programme, the following questions were asked in the interview:

> Does the present 2PC (2-year Primary Certificate) course have any influence on your science teaching? What are the influences?

Regarding the student-teachers' experiences in their teacher education programme, some of them (9 of 13 student-teachers) (Table 4d) recalled a positive experience in studying the General Studies curriculum studies or Science Academic Studies modules in their previous year of study. The programme offers a General Studies Curriculum Studies module that covers the methodology and approaches to teaching the subject as a whole, and science teaching contributes to about 3 hours out of the 30-hour module. The Science Academic Studies module aims to strengthen the student-teachers' knowledge in science with an understanding that most of them have an arts background in secondary school. The Academic Studies module was described as helping them to strengthen their scientific knowledge, as illustrated by the following example:

> What is taught is important and is related to teaching at primary level. I can have a better understanding of the subject. The methods modules are also very important. With more background in the subject, I can better answer pupils' questions and be able to explain in a different way if pupils don't understand. I can have a better understanding of topics about space; usually pupils have many questions about these topics. It would be embarrassing if I

> cannot answer their questions. It is advantageous for us to know more about the topic. (Ki1)

Table 4d Student-teachers' learning experiences in the teacher education programme
(N=13)

Learning Experiences in the Teacher Education Programme Does the present 2PC (2-year Primary Certificate) course have any influence on your science teaching? What are the influences?	**Occurrences in the interview data**
Positive views about the Academic Studies module	4
Negative views about the Academic Studies module	3
Positive views about the Curriculum Studies module	5
Negative views about the Curriculum Studies module	1
Influenced by Teaching Practice	2
Became more capable in answering pupils' questions	1

Although the Academic Studies module may be perceived as strengthening their understanding in science, others (3) described the module as not helpful, and one found that the Curriculum Studies module in year one lacked a clear direction in the teaching approach.

> The Academic Studies module is too difficult for the level of primary science teaching. I also understand that this can help us to think about how to make the presentation of the content more suitable to the pupils. However, I was not too attentive in the lectures. This module could not really help me. (Ai1)

From this quotation it can be seen that the student-teacher was not motivated to learn in the Academic Studies module. Apart from finding the module too difficult, the students (2) found that the content could not be applied to their teaching practice:

> The content (academic knowledge) that we learn is very in-depth and we may not know how to present them in a simpler way to the pupils (in the teaching practice)... The course should teach simpler things that are directly applicable in our teaching. (During the teaching practice,) the application of science content in the programme is not as great as in other subjects like Chinese and mathematics. (Ii1)

Although not all of the student-teachers recalled particularly strong positive or negative feelings about their previous learning in year one of the teacher education programme, those who related positive or negative experiences may be influenced in their future learning in the Curriculum Studies module or in their science teaching.

4.4.2 Learning experiences in the primary and secondary schools

In the first session of the Curriculum Studies module, the student-teachers in the whole group of thirty-nine were asked to describe, by writing on a blank piece of paper their past learning experiences in science. The student-teachers had mixed feelings about the learning of science in their past educational experience. A total of fifteen student-teachers shared an interest in learning the subject. Among them, eleven found that it was exciting to conduct practical activities. However, the majority (33) of the student-teachers had described science as a difficult subject to learn or to understand. Twenty-nine of the student-teachers related negative feelings in learning the subject which included finding the subject boring, being uninterested and fearing learning it. Only a minority (11) in the class shared positive feelings of finding science exciting and fun to learn. This provides a brief picture of the perceptions of the student-teachers.

To obtain a picture of the influence of their past educational experiences on their teaching, the following questions were asked in the interviews with the thirteen student-teachers:

> Can you describe your past experience in learning science? (Did the teachers who taught you before have any influence on your teaching? What are the influences? OR Did your experiences as a student have any influence on your teaching? What are the influences?)

A similar situation was found (Table 4e). Regarding their previous learning experiences of science as a subject in their primary or secondary school, ten of them described negative experiences. For example:

> It was easier before Form 3 and later it became very abstract.

> There are Physics, Chemistry and Biology in Form 3. There are equations, which are very abstract and are difficult to understand. Biology is more concrete; the other two subjects are very abstract. My achievement was not good and I am not happy about it...Sometimes I didn't know what the teacher was doing in class. (Di1)
>
> It seemed to be very difficult and there were a lot of terms to remember in English. The teaching pace was very fast. It did not seem applicable. The teacher taught in a boring way, we only studied to get through the examination and forgot what we had learnt afterwards. I found it very difficult, spelling, dictation and if we could not answer a question, we had to stand for the whole lesson. It seemed that we did not have enough apparatus around. Six or seven of us shared one set, it was usually dominated by the boys and we (the girls) had a chance to touch them only after the practical and in cleaning up. (Hi1)

Science was found to be abstract and hard to understand. There were problems with the teaching approaches adopted by the teachers and the students experienced low achievement.

Table 4e Student-teachers' past experiences of learning science in primary and secondary school
(N=13)

Past Learning Experiences Can you describe your past experiences in learning science? (Have the teachers who have taught you before had any influence on your teaching? What are the influences? OR Did your experience as a student have any influence on your teaching? What are the influences?)	**Occurrences in the interview data**
Positive	3
Negative	10
Low achievement	2
Difficult	4
English terms made the learning of science difficult	4
Could not understand the content	1
Depended on the teaching strategy of the teacher	2
Afraid to fail	1
Studied to get through examination	2
A lot to remember	2
Boring	2
Competition was keen to enter into the science stream at the senior secondary level	1
There was a quota in science stream and failed to study science	1
Science concepts are abstract	2
Choice of study was influenced by brother	1
Girls only do the washing in the practicals	1
Interested to read about science	1

Four out of the thirteen student-teachers had difficulty in studying the subject through the medium of English and two of them described the subject as having a lot of things to remember. They also had problems with the teaching strategies of their teachers. Their main concern as students was to study or to remember enough to get through the examination. The feelings associated with the learning process in the science lessons were represented by words like boring and fear. They described the subject as difficult and abstract. Two respondents related the social influences on their study, one being an influenced by his brother and the other suggesting that girls were disadvantaged in studying the subject. Two other respondents had hoped to study science in their upper secondary schooling but were unable to do so due to the limited quota for the science classes in their schools.

Despite the majority perceiving science learning as a negative experience, three respondents described a positive experience. For example:

> It was fun. I found science experiments interesting. There was a problem with my secondary school as people said that all the science classes failed in their public examinations. I thus chose the arts stream. Science to me was fun. The teacher let us perform the practicals, I would then think about the problems... I might not have learnt too much science but the feeling was good and it was not as boring as subjects like Chinese History. The science teachers were quite good. (Ai1)

These student-teachers developed an interest in science, which is an important attribute for a science teacher. Another respondent related an interest in the subject; however, his interest was not properly developed, due to the competitive examination system:

> Actually I would very much have liked to take science. However, I could not take science, as the competition in my school was keen. I read on my own to enrich my knowledge in science. I read books and magazines, etc. The teachers were boring; there were only demonstrations. Language (English) was a difficulty for me. In the examination, I could not express my answers or I spelt the terms wrongly. Science was fun but learning science in school was a pain. (Gi1)

In summary, the majority of the student-teachers had negative science learning experiences in their primary and secondary education. They found the subject difficult, abstract, boring and experienced failure in getting into the science stream at their senior secondary. They had more positive experiences with the Curriculum Studies module than with the Academic Studies module. The learning of the science content knowledge in the Academic Studies module was found to be another negative experience by three of the respondents who described it as difficult and irrelevant for teaching at the primary level. These experiences may have had a negative influence on their confidence to teach science, and the student-teachers may find it hard to understand what is meant by good science teaching without having a successful experience in learning science themselves.

4.5 Feelings about teaching science in the General Studies curriculum

In the first session of the curriculum studies module, all of the thirty–nine student-teachers taking the module were asked to write down how they felt about having to teach Science in the General Studies curriculum. In relating their feelings about having to teach Science, fourteen of them mentioned worries concerning their knowledge of the subject, about how to handle science concepts and answer pupils' questions. Twelve mentioned difficulties in handling practical activities and twenty in adopting effective teaching strategies. Their worries in teaching included the difficulties of arousing pupils' interest, helping pupils to learn science concepts and the expectations of themselves as teachers to have good preparation and clear scientific concepts. Negative feelings were mentioned by fourteen student-teachers, while only four teachers shared positive feelings. Words like "fear", "feeling defeated", "feeling helpless" were used by the student-teachers who had negative feelings. This summary provides a brief overall picture of the feelings of the student-teachers before they started the Curriculum Studies module, while more detailed comments were collected in the interviews.

In the interviews with the 13 student-teachers, they were asked to describe how they felt about having to teach Science topics in General Studies. They expressed much concern about their teaching of science topics, and negative feelings towards the teaching of science content were mentioned by all the respondents (Table 4f). Ten respondents were worried about the content and three about conducting practical activities in class. For example:

> I have some worries, I do not have enough knowledge, and the pupils may ask more difficult questions. Compared with the Social Studies and Health Education content in the GS (General Studies), I would prefer to teach these rather than the science content. I am not sure whether I can really handle the apparatus or not. (Hi1)

> I am afraid. I have more confidence in teaching the topics that are more related to our daily life. For the Physics topics, I find it more difficult and have limited knowledge. (Li1)

This is consistent with their responses to the previous questions on lesson preparation, as the major concern was with the content and in conducting practical activities. Other worries include finding the appropriate resources (1) and classroom management (1) such as:

> As I know in my teaching practice, the schools do not have adequate resources for teaching the subject. I don't know much about the teaching approach and together with the lack of resources, it is very difficult. (Ji1)

Table 4f Student-teachers' feelings about having to teach science content in the General Studies curriculum
(N=13)

Feelings about teaching science content in the GS (General Studies) curriculum	**Occurrences in the interview data**
Worry	6
A bit frightened	1
Not much confidence	2
Afraid	1
Difficult	4
Incompetent	1
Psychological burden	1
Challenging*	1
Confident*	1
Reasons for the feelings	
Worried about having sufficient academic knowledge to teach the content	7
Felt embarrassed if failed to answer pupils' questions	1
Do not know how to represent content in an understandable way	1
Worry about conducting practical activities	3
Lack of resources in schools	1
Cannot manage the class	1
Involves teaching abstract concepts	1
Hope that pupils can learn in a different way*	1

* Positive feelings in the list.

One of the student-teachers hoped that his pupils could learn science in a way different from his own experience:

> I am interested to try to teach the subject. I hope that my pupils can learn in a different way and not only follow the text. (Hi1)

Despite having experienced negative past learning experiences in science, this student-teacher is willing to try and provide a different experience for his pupils. The main problem for the teacher educator is to find a way to help the student-teachers with low confidence levels and negative learning experiences of science behind them, to develop their professional competence and confidence in science teaching.

4.6 Summary

This chapter described the prior views about science teaching and learning held by the student-teachers before they took the Curriculum Studies module. The analysis suggests that the student-teachers had placed much emphasis on teaching the content knowledge in science, although a small proportion of them were aware of the importance of developing the ability to think among the pupils. They equated science teaching with conducting practical activities and had little consideration of engaging pupils in thinking. The majority of the student-teachers had previous negative science learning experiences in their secondary and primary education, and had experienced failures in the examination system. The experience of learning science in the teacher education programme was diverse, some of the student-teachers realized how the learning in the modules in the previous year influencedthem in the process of learning to teach, while others failed to realize this. It appears that the negative science learning experiences in their previous education may have an impact on their perceptions about science teaching. They shared much worry over teaching science and the anxiety over the content to be taught was great. There were also worries over conducting practical activities and answering pupils' questions.

The concerns and feelings of incompetence shared by the student-teachers in the present study are similar to the findings in another local study on in-service primary General Studies teachers (So, Cheng and Tsang, 1996). As suggested in the literature described in Chapter 2 (Section 2.4.2), the teacher educator needs to acknowledge the past learning experiences of the student-teachers and help the student-teachers to reconsider their views of science teaching. The next chapter describes the learning experiences of the student-teachers in the Curriculum Studies module with an aim to understand the changes and development that the student-teachers experienced in the process of learning to teach.

Chapter 5

Learning in the Curriculum Studies module

5.1 Introduction

The Curriculum Studies module as an intervention in this study aimed to help the student-teachers to teach science based on a constructivist view of learning. Moreover, the data collection was focused to find out the learning experiences and the development of the student-teachers during the Curriculum Studies module as a part of their pre-service teacher education. In order to describe the learning experiences and the development of the student-teachers, the findings from the questionnaire (39 student-teachers) are reported together with the results from the interviews (13 student-teachers), although the findings from the interviews contribute to the main framework of analysis. In addition, the discussions in the module sessions (thirty-nine student-teachers) are also reported to illustrate the learning outcomes of the student-teachers in the module.

In the quantitative part, a questionnaire was designed to find out the changes in the confidence and the conceptions about science teaching among the student-teachers before (questionnaires in Appendix C1, C2, C3) and after (questionnaires in Appendix C2 and C3) they took the Curriculum Studies module. The changes in conceptions of teaching were compared before and after the module. The number of respondents at the first and second round of collecting the quantitative responses were 39 and 36 (3 students were absent). The questionnaires were distributed during the lecture hours and were collected immediately after the respondents had completed them.

The results of the questionnaires before the Curriculum Studies module (Table 5a) show that the majority (77%) of the respondents had had science teaching experiences in their first year, and of the 13 teachers, 5 had taught science in Year One. None of the respondents had a science background in their secondary education, and 64% were female. Seventy-seven percent had some science teaching experience in their teaching practice of the previous year. Eighty percent regarded teaching as their first career choice and ninety-two percent felt an enthusiasm to teach. The demographic characteristics were congruent with the characteristics of the student-teacher population of the Hong Kong Institute of Education.

Table 5a Demographic characteristics of the informants
(N= 39)

Characteristics		**Percentage**
Gender	Male Female	35.9 64.1
Background	Arts Science	100 0
Previous full-time working experience	With Without	51.3 48.7
Previous full-time teaching experience	With Without	5.1 94.9
Taught science in the previous teaching practice	Yes No	76.9 23.1
Teaching as the first career choice	Yes No	79.5 20.5
Enthusiasm to teach	Yes No	92.1 7.9

The following sections report the learning experiences of the student-teachers as analysed from both the qualitative and the quantitative findings of the study. The analysis starts with an examination of the learning experiences of the student-teachers during the Curriculum Studies module.

5.2 Science learning experiences of the student-teachers

In view of the low level of confidence among the student-teachers in teaching science and their arts background (Section 4.5), the Curriculum Studies module was designed in the study with an aim to introduce an array of teaching strategies in science teaching with special emphasis on the constructivist view of learning. Particular emphasis in the module was placed on letting the student-teachers experience being taught in a way which was consistent with a constructivist view of learning. This section reports the data that were collected from two sources:

- the discussions in the module sessions with the whole group (39) of student-teachers;

- the interviews with the 13 student-teachers after the module was completed (Chapter 3, Section 3.3.2.1 ,Appendix A2).

5.2.1 Findings from the student-teachers' discussions during the module sessions

In the module sessions, the student-teachers experienced the various teaching approaches (the discovery approach, the process approach and teaching science based on a constructivist view of learning). After each activity they (thirty-nine) were asked to discuss the following questions in small groups of three to four:

- How did I learn in this approach?
- What was the role of the teacher in this case?
- How did I feel about this approach to teaching and learning in science?
- In this approach what assumptions are made about the nature of science?

The aim of the discussion was to let the student-teachers draw upon their experience and discover the implications for learning and teaching using the different approaches. After the group discussion, each group then reported their conclusion to the whole class; the following descriptions were summaries of their reports. The following descriptions were discussion notes (Discussion notes 1 to 6) translated from their reports. These findings provide an overview of what the whole thought about teaching science based on a constructivist view of learning.

Though the above discussion questions were applied to each of the teaching approaches that the student-teachers experienced in the module, the following section summarizes the discussions about teaching science based on a constructivist view of learning.

> How did I learn when the lecturer taught science based on a constructivist view of learning?
> - Learn through own experience, communication, and interaction. Observation, recording, comparison and analysis.
> - Find out the answers through the practical activities. Interact with classmates, find out the questions, and then use the practical activities to find out the answers. Correct own misconcepts and develop more knowledge in science.
> - Ask questions. Then suggest ways to find out the answers.
> - To learn through experience, to develop pupils' previous knowledge and correct their wrong concepts. Interact with pupils and find out the problems together and then find the

> answer through the practical activities. (Discussion notes 1)
> (see Chapter 3, section 3.4.2 for a description of the coding)

Although the question itself asked the student-teachers to identify their own experiences as learners, they started to compare their own learning with that of teaching the pupils, in the discussion. The student-teachers emphasized the significance of interaction with classmates and compared this with the interaction with the pupils in their teaching. In this comparison, the two levels of interactions were involved; the interactions between the learners and the interactions between the teacher and the learner. The student-teachers noticed the development of concepts and starting from previous knowledge as a basis for learning. They also identified that the learners' role was active in asking questions and in finding out answers as well. These are views that are consistent with the constructivist view of learning.

> What is the role of the teacher if he/she is teaching science based on a constructivist view of learning?
> - To discuss, and as a facilitator
> - To help pupils to think about problems, let pupils find out the answers and conclude.
> - Explain the procedure and help the pupils.
>
> (Discussion notes 2)

From this discussion, the student-teachers acknowledged the role of the teacher in discussing with pupils, in getting them thinking and helping them to assume an active role in finding out the answers. The student-teachers also reported on their feelings about teaching and learning science:

> How do I feel about teaching and learning science based on a constructivist view of learning?
> - Interesting with different types of experiments.
> - Able to develop in pupils an ability in problem solving.
> - Pupils are willing to take part. Can clarify one's concepts through the activities. Can also make abstract knowledge become more concrete and make it easier for pupils to master.
> - Pupils can find out the questions by themselves and then find out the answers. Develops a deep impression in pupils. Helps pupils to be independent learners. Pupil and teacher interactions are important.
> - Develops in pupils the ability to learn independently and find out the questions.
> - Not enough time. Pupils' previous knowledge cannot match with the teaching content.
>
> (Discussion notes 3)

The student-teachers found that teaching science based on a constructivist view of learning provided a better learning condition in terms of arousing pupils' interest; increasing their participation and helping them to become independent learners. However, some misunderstood and equated this approach with conducting practical activities. Nevertheless, they were able to identify reasons that support better learning outcomes among the pupils. These reasons included: clarifying concepts; making abstract concepts more concrete; pupils assuming a more active role in learning and resulting in better learning. The importance of pupils and teacher interaction was again mentioned under this question showing that the student-teachers were impressed by the learning outcomes that they achieved as a group during the discussions. Despite the positive feelings about the learning, some of the student-teachers raised the practical limitations about the time available and the difficulty of changing pupils' preconceptions. Moreover, the student-teachers made some conclusions about the assumptions made about the nature of science as science is taught based on a constructivist view of learning:

> In this approach what assumptions are made about the nature of science?
> - A spiral approach in learning, to find out questions and experiment again and again.
> - To learn through experience and discussion with classmates.
> - Science knowledge is shared by people as they talk about it.
> - Science needs to be proved, hypothesized. Raise questions, find own answers, self-reflection, solve the problems by oneself and helped by other classmates.
>
> (Discussion notes 4)

It appears that the student-teachers were aware of the continual search for science knowledge and that the knowledge is shared among people. In the responses, both the learning experienced by the individual and by the group of students was valued by the student-teachers themselves. Learning science was not seen as a solo activity but was found to require discussion with and help from others in the class. Finally in the discussion, the student-teachers summarized what they think were the advantages and disadvantages of teaching science based on a constructivist view of learning:

> The advantages of teaching science based on a constructivist view of learning as identified by the student-teachers are as follows:
> - Ensure that pupils are thinking
> - Teacher and pupils are involved in thinking

- Teachers and pupils can communicate about what they think
- Teachers and pupils own the knowledge together
- Involve reflection
- Improve pupils' ability to solve problems
- Develop their self-learning ability
- Pupils formulate their own questions
- Correct and enrich pupils' previous knowledge
- Reinforce pupils' concepts
- Can change preconceptions

(Discussion notes 5)

The disadvantages of teaching science based on a constructivist view of learning identified by the student-teachers:

- Pupils have very different preconceptions
- Difficult to change pupils' preconceptions
- Difficult to take care of individual differences among pupils
- Do not have a similar learning experience in previous education
- Different questions raised by pupils

(Discussion notes 6)

The student-teachers appreciated teaching science based on a constructivist view of learning as teaching that involves pupils in thinking as well as acknowledges and develops pupils' preconceptions. However, they also realized the difficulties associated with changing pupils' preconceptions and the possible diversity of pupils' preconceptions.

This section has provided a picture of the learning experience of the student-teachers during the module sessions. From the experience of the researcher as a teacher educator, the learning outcome of this group of student-teachers was very satisfactory, keeping in mind that these were students who had had negative past learning experiences in science and who described their fear and worry about teaching the subject at the beginning of the module. The teaching approach that allowed the student-teachers to experience the various teaching approaches as learners had an influence by getting them to reflect on the implications afterwards from the position of a teacher. There was better learning by the student-teachers as they were able to: draw comparisons between their learning experiences and those of the pupils; identify the implications of the constructivist view of learning in teaching; find out the conditions that encourage pupils' learning, and explain why better learning by their pupils may occur. It appears that the strategies adopted by the researcher, for example, modelling the teaching approaches, and encouraging the student-teachers to reflect (Section 2.4.2) in the Curriculum Studies module has facilitated better learning among the student-teachers.

5.2.2 Findings from the interviews with the student-teachers after the module was completed

The experience of the student-teachers and the feelings about learning to teach science can suggest two implications for the present study. Firstly, these may provide a picture of whether the student-teachers were likely to implement the science teaching strategies based on a constructivist view of learning introduced in the module. Secondly, these may suggest whether the intervention strategies employed by the researcher in the Curriculum Studies module were helpful in facilitating the development of the student-teachers. The perceptions of the student-teachers about the Curriculum Studies module were elicited during the interviews after the module using the following questions:

> How do you feel about studying the Curriculum Studies module? Has the module had any influence on your science teaching? What are the influences?

The findings are summarized under three headings in this section:

- feelings about learning;
- the module content;
- the learning process in the sessions.

The student-teachers generally shared positive feelings about the Curriculum Studies module. Twelve out of thirteen of the respondents in the study found that the Curriculum Studies module was a positive science learning experience (Table 5b). They found the learning process to be interesting and were more confident about teaching science even though they may still experience some difficulties, for example:

> This module was more interesting than the Science Academic Studies module. (Bi2) (see Chapter 3, section 3.4.2 for descriptions of the coding)

Table 5b Student-teachers' perceptions of their experiences in learning science teaching in the module
(N=13)

Student-teachers' comment about learning in the Curriculum Studies Module (How do you feel about studying the Curriculum Studies module? Has the module had any influence on your science teaching? What are the influences?)	**Occurrences in the interview data**
Feelings about learning	
Positive learning experience	12
Interesting / fun	6
Feel more confident than before	1
Feel some difficulty	1
The content of the module	
The module was not as difficult as the Academic Studies module	7
Approaches learnt will influence future teaching or are helpful	2
Expect to be effective in using the approaches	1
Becomes clearer about the organization of topics using pupils' concepts as a basis	1
Having learnt the approaches, feel one-self more professional/ Have learnt how to teach	2
Would want to learn more about science education	1
The learning process	
Felt it difficult to learn by one-self	1
Enjoyed sharing views in teaching	1
Enjoyed participation and atmosphere	1
Emphasis on thinking and analyzing	3
Role of learner should be more active	1
Experience the approach or the process is important	3
Learn through teaching based on a constructivist view of learning	1
The process is lively	1
Negative Comments	
Boring and lacks driving force in studying the module	1
Prefer to learn by reading and the lecturer talking about the various teaching approaches	1

We experienced the approaches through the practical activities. It was fun. (Gi2)

I find learning interesting and as there were practical activities, the sessions were fun. (Ji2)

It was more interesting to work with classmates. I could grasp the content better...(Mi2)

I liked studying the module. Before I was afraid to teach the subject and thought that it would be best if I could avoid teaching the subject. Having completed the module, worked through the

> assignment and gone through the written test, I feel that I know more about how to handle the subject. I can follow the module well. I feel quite good during the lessons. (Ii2)

> At first, there was some difficulty and I tended to mix up the approaches. Later, I could distinguish the differences and grasp the characteristics in each. (Ei2)

The Curriculum Studies module had apparently provided a positive learning experience for the student-teachers. The student-teachers (7)[1] felt that the content of the module was not as difficult as the Academic Studies module on science knowledge. Furthermore, they identified the complementary nature of the Curriculum Studies (CS) and the Academic Studies (AS) module from their learning experience. For example:

> The AS module is more on the content. The CS is on the teaching approach. The two are complementary; I may have forgotten the subject knowledge after all these years. After learning these, I would know how to teach through the CS. I feel happier in studying the CS....CS looks easier but is more difficult if you really want to put it into practice. The AS is just on memorization; there is nothing difficult about it. I like the CS more. (Li2)

This student-teacher had identified the different emphases of the two modules. Moreover, the Curriculum Studies module was found to be helpful for preparing them to teach. One found himself clearer about the organisation of topics having known pupils' ideas, and another expected herself to be effective in using the approaches. For example:

> The science academic studies module was difficult. The Curriculum Studies module is not on how much scientific knowledge I have. It is on the method of teaching and is helpful in my teaching. It is not as difficult. The notes are simple to understand. I have experienced the various teaching approaches and I can feel the advantages or disadvantages of each. It is not as difficult. I become clearer about how to develop pupils' concepts, which experiment or topic should go first becomes more obvious. My planning will be improved. (Ci2)

In helping them to teach, the student-teachers were able to notice the importance of developing pupils' science concepts through the module, which is one of the

[1] The number in brackets represents the number of student-teachers mentioning this in the interviews.

major characteristics of the constructivist view of learning:

> It becomes clearer about how to develop pupils' concepts, which experiment or topic should go first becomes more obvious. My planning will be improved. (Ci2)

The student-teachers indicated that the module has helped them to become more professionally equipped with the understanding about the various teaching approaches, for example:

> The teaching approaches that I have learnt in the module will greatly influence my teaching in future. (Ai2)

> With the knowledge of the different approaches, I feel myself more professional. (Gi2)

About the learning process, the student-teachers were able to realize that as they commented about the participation (1), sharing of views with each other (1) and assuming an active role were helpful in the process of learning to teach. For example:

> I have the chance to experience different teaching approaches.... We can share our views on different approaches and can improve our teaching. (Bi2)

> I am happier this year and we can participate a lot. The atmosphere was good. How much we can learn depend on ourselves. The Academic Studies module is taught through a transmission approach and we can actually read these up from textbooks. In the Curriculum Studies module, we really need the lessons. (Gi2)

They (3) indicated that an emphasis on thinking and analyzing in the learning process during the sessions of the Curriculum Studies module was helpful, for example:

> We do not learn the results in the practical activities but realize how we think in the process. We consider the role of the pupils and the teachers in the process. The process is lively and there is less pressure. There is less memorization. The process of thinking and analysis is more important in this module. (Ei2)

> The Curriculum Studies module is on understanding and analysis. We don't need to memorize but to understand. (Hi2)

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> The Curriculum Studies module is on understanding and analysis. We don't need to memorize but to understand. (Hi2)

> It is different for the Curriculum Studies and is less difficult. We do practical activities and reflect on the activity. We consider the role of the pupils and how pupils think. (Mi2)

The above quotations demonstrated how the student-teachers defined the significance of thinking, analysis and understanding in helping them to learn. From this experience, they drew comparisons with the learning of their pupils and in stimulating pupils to think or learn in a similar way. Hence, the student-teachers were able to draw comparisons of their own learning experience with their pupils learning science. They said that they themselves had learnt through teaching based on a constructivist view of learning and that experiencing learning through the various teaching approaches was important, for example:

> In the Curriculum Studies module, we experience the approach, discuss the theories and we then try out the lessons. This is different and I feel that the approaches are applicable...We learnt through teaching based on a constructivist view of learning as well. I have learnt more about science teaching approaches. (Ji2)

> We experience the approaches through the practical activities and the activities. (Hi2)

Despite the general positive comments about the learning experience in the module, two negative comments were obtained. One of the student-teachers did not appreciate the experience of having to think and discuss in the sessions. This can be interpreted as an influence from the student-teachers' past education experience when teachers in Hong Kong generally adopted a transmission approach. The learning experience in the module did not succeed to change his views about the teaching and learning of science.

The student-teachers have related their experiences of failures in science in their secondary schooling (Section 4.4.2). Moreover, in the interviews before taking the Curriculum Studies module, they expressed their worry for the content to be taught (Section 4.5). The module has provided an opportunity for them to rebuild their confidence by sharing a positive science learning experience. Through this experience, they have drawn parallels between their own and their pupils' learning. The worry about content also decreased with the general increase in confidence in science teaching. For the present study, as the student-teachers were going to become primary science teachers, the positive learning experience in the Curriculum Studies module may help to build up their confidence in teaching science. Moreover, the positive experiences may also suggest that the intervention strategies in the module have facilitated the development of the student-teachers.

5.3 Views of science learning after the Curriculum Studies module - the importance of learning science content in the primary curriculum

The student-teachers' views about science learning may influence their views about science teaching, and changing their views towards a constructivist view of learning may be considered as a form of teacher development. The views about science learning were collected in the interviews with the thirteen student-teachers after the Curriculum Studies module (Appendix A2, Chapter 3, Section 3.3.2.1) with the questions:

> What do you think is or are the important things that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?) Have your views changed? If so how and why?

Before taking the module, 8 out of 13 student-teachers considered science learning as learning basic concepts to establish a foundation for future learning (Section 4.2). After taking the module, though the number and nature of categories of response remained the same (Table 5c), their views were more diversified with increased in awareness of developing process skills (5), an interest in science (2), and an investigative attitude or active role in learning among the pupils (4). These were more frequently mentioned in the interviews after the module. The importance of self and continuous learning among the pupils was emphasized by four of the student-teachers, as one commented:

> Time is limited during the lessons. We teach part of the content and hope that the pupils will continue to learn outside the classroom.... Now I think that pupils should not learn only when the teacher is there to tell them. They should find out more by themselves. They would have a deeper impression (impact) by

> assuming a more active role in learning. (Ci2)
>
> The attitude. Life long learning is more important. The attitude of trying to find out more about science is more important. It would be useful throughout their lives. (Gi2)

Table 5c Student-teachers' views on the importance of science content in the primary curriculum after taking the Curriculum Studies module (N=13)

Importance perceived by the student-teachers	**Occurrences before studying the module**[Δ]	**occurrences after studying the module**
To learn science knowledge: basic concepts in science, knowledge as a foundation for future learning	8	3
To develop process skills: ability to hypothesize, evaluate, communicate, observe, measure and record	1	5
To develop an attitude of finding out and investigation, self-learning, taking a more active role in learning	2	4
To develop an ability to think, analyse, understand Build up a "schema" to help to understand other knowledge	3	3
To develop an interest in learning science	1	2
To learn something that is related to daily life experience and to apply it	5	5
To learn how to do practical activities	1	0

[Δ] Findings reported in Table 4a with categories reorganised.

The interest in learning science as mentioned by two of the student-teachers was taken as related to continuous and active learning among the pupils.

> Their interest in science is more important than to build up basic knowledge.... This would be a driving force for continuous learning in the future. (Fi2)

It is important that the student-teachers valued not only the learning of content but also engaging the pupils in thinking; developing an attitude for investigations and developing in their pupils an interest in science. These are the conditions that may lead to continuous learning outside the classroom or life-long learning as it was referred to by one of the student-teachers. Apart from the diversity of responses, the quality of responses also differed. After studying the Curriculum Studies module, the student-teachers could better articulate what was meant by getting pupils to think. For example:

> As a teacher, there are many ways to teach science. There are different possibilities and ways to stimulate pupils to think. There are different practical activities for teaching a topic. (Bi2)

> They should be able to extend their understanding to something that they have not learnt before. They should be able to build up a schema and use this to understand something that they have not learnt before. (Di2)

From this, stimulating pupils to think may be achieved by practical activities and means to learn new ideas, as well as applying the way of thinking to learn continuously. It appears that the module had widened the views of the student-teachers on science learning and prepared them to accept and try-out different strategies in science teaching, including teaching based on a constructivist view of learning. In addition, the student-teachers had adopted a constructivist view of learning by hoping that their pupils would assume a more active role in learning by engaging in self-learning and in thinking. These views on science learning were more diverse in considering the thinking of the pupils than the responses made before the module (Section 4.2) when the importance of learning science was emphasized only in the content knowledge and in performing practical activities. Moreover, the student-teachers compared their own learning experiences in the Curriculum Studies module with science learning among the pupils by saying, for example:

> I think that it is the process of finding out, the ability to analyse and understand that are more important. The pupils may know already the science knowledge, these are less important. It is pupils' thinking processes that is important... Before I may have regarded science knowledge as being more important. The answer should be learnt. Now, I put more emphasis on the why, how and process of learning. I feel this in the activities that we have done in the module. I have to reflect on the activities and about the role of the teacher and learner. It makes me feel that the process is important. (Ai2)

From the findings in the previous section 5.2.2, the student-teachers had shared positive feelings in the module, and in the above quotation the student-teacher had also compared their own learning experiences with those of the pupils. By experiencing the learning activities, they could better identify themselves with the role of a teacher who helped the pupils to think in class. It may be interpreted that modelling the teaching advocated in the Curriculum Studies module facilitated the development of the student-teachers (Section 2.4.2).

By having more diversified concerns than just learning the content and being reflective of their learning experiences, these respondents can be viewed as having experienced positive professional development. With a more diverse view of the purpose of science learning, they have shifted significantly from placing greater emphasis on learning the science content to an awareness about developing an interest in, and positive attitudes towards learning. However, this shift did not occur among all the student-teachers, as 3 out of 13 of the respondents still retained the view that learning science content is the most important aspect of science learning.

In the interviews after the Curriculum Studies module, the student-teachers were asked to describe the relative importance of science as compared with other subjects. The responses to this question, "Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc.? Have your views changed? If so how and why?" are summarized in Table 5d. Although the number of student-teachers who thought that science was of equal or greater importance than other subjects had increased from three (Section 4.2) to five after the module, eight of them still allocated more importance to the subjects that were examined. As a result, only two of the thirteen student-teachers shifted their opinions from thinking that science is less important than other subjects to thinking that science is equally important. Six of the student-teachers related the importance of learning science as an area that develops pupils' thinking, promotes environmental awareness among the pupils, and includes subject content related to daily life. However, the others thought that it was just common knowledge (1) and the importance of a subject was proportionate to the curriculum time available in school (1). Given the fact that the pupils' achievement in General Studies do not carry any implications for secondary school places allocation, and that the curriculum time spent in General Studies is only half of the time for any of the three other subjects, namely Chinese, English and mathematics, it is not surprising that the views of the student-teachers regarding the importance of science learning did not shift significantly after studying the module. It appears that the school and curriculum context influence how science should be taught and what are considered to be the value of teaching a subject. Despite this, the slight shift among the student-teachers towards giving science more importance may be taken as an influence of the learning experience in the Curriculum Studies module.

Table 5d Student-teachers' views on the relative importance of the subjects as compared with other subjects after taking the Curriculum Studies module (N=13)

What do you think is or are the most important thing that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?) Have your views changed? If so how and why?	**Occurrences in the interview data**
Relative importance of the subjects	
Maths and Science are equally important/ Maths, languages and science are more important than the cultural subjects/ All the subjects are of equal importance	5
Chinese and English are more important than other subjects	5
Chinese, English and Maths are more important than other subjects	3
Reasons regarding relative importance of the subjects	
Develop pupils' ability to think/achieve deeper understanding/ The subject contents are related to daily life / Should promote awareness of the environment among the pupils +	6
Learning languages enables pupils to learn by themselves	1
Science is just common knowledge	1
Chinese and English take up more curriculum time and are thus more important	1

+ Reasons that support science as an important area to learn at the primary level.

5.4 Views of teaching science after the Curriculum Studies module

As the present study looks into the development of the student-teachers in the process of learning to teach, the shift in views of teaching may be interpreted as the influence of the Curriculum Studies module. This section describes the changes in the views about science teaching among the student-teachers after they completed the Curriculum Studies module (Appendix A2, Chapter 3, Section 3.3.2.1). The following questions were asked during the interviews:

> With reference to science teaching, what are the steps in your lesson preparation?
> When you teach science, what are the most common strategies that you would employ?
> What are the principles in choosing those strategies? (Or What do you remember about the strategies that we have covered in the module? What do you think about their applicability in your situation?)

The following analysis includes mainly the qualitative data summarized from the interviews with the thirteen student-teachers and is supported by the quantitative data obtained from the questionnaires (Appendix C1, C3) of the whole group of thirty-nine student-teachers where appropriate. The student-teachers' views of science learning are reported under:

- concerns and strategies during lesson preparation, and
- teaching strategies and activities to be adopted in teaching science.

5.4.1 Concerns and strategies during lesson preparation

Before taking the module, the main concerns expressed by the interviewed student-teachers during preparation for science lessons were designing activities and studying the content to be taught (Section 4.3.1). After taking the module, more student-teachers (5 out of 13) (Table 5e) shared the concern for identifying what pupils have learnt before the lessons and made considerations based on a constructivisit view of learning. They described their teaching as related to the preconceptions held by the pupils. For example:

> I would find out about what pupils know about the topic. Before the lesson, I would ask them some questions to find out what they know. (Fi2)

> I would ask the pupils some questions before the lesson and adjust my teaching accordingly. (Ki2)

> It would be good to know about pupils' preconceptions. I would start from there and develop my teaching based on that. (Ji2)

Another strategy raised that was consistent with a constructivist view of learning was about planning to stimulate pupils to think in class (mentioned by one of the student-teachers):

> I would provide the stimulation, the environment to get pupils thinking in the lessons. I would ask more thought-provoking questions. Let pupils find out the results. (Ai2)

Table 5e Strategies for preparing lessons as reported by the student-teachers (N=13)

Strategies as reported by student-teachers (With reference to science teaching, what are the steps in your lesson preparation?)	**Occurrences before studying the module**$^{\Delta}$	**Occurrences after studying the module**
Items that showed an increase after the module		
Consider what pupils have learnt before	1	5
Stimulate pupils to think in lessons or Ask thought provoking questions	0	1
Prepare for questions from pupils	1	2
Stimulate pupils to recall their own experiences	0	1
Reflection on different teaching approaches	0	4
Think of ways to impress/ attract pupils' attention	1	2
Try out practical activities	1	3
Collect information about the topic (including activities and children's ideas)	0	3
Items that showed a decrease after the module		
Consider the aims, and design appropriate activities and practical activities	8	7
Prepare teaching aids	4	1
Design worksheets/ questions	1	0
Study the content and be clear about the topics to be taught (from textbook)	5	3
Read up the content/ Consider the content to be taught (from other sources)	7	4
Relate content to daily life experiences	1	0

$^{\Delta}$ Findings reported in Table 4b with categories reorganised for comparison.

The student-teachers were prepared to ask more questions in class. One thought about how to stimulate pupils to ask more questions. He suggested achieving this by getting pupils to recall their personal experiences:

> Science knowledge is related to their daily life experiences. If I can relate the knowledge to life, they can learn better. I would just stimulate pupils to recall their own experiences...I can ask them some questions before the lesson or stimulate them to ask questions through an activity. (Ci2)

The various teaching approaches introduced in the module would also become strategies that the student-teachers (4) might consider in their teaching in the coming teaching practice, for example:

> I would read the notes and reflect on the different teaching approaches. I would lead pupils to think. I would provide the stimulation and the environment to get pupils thinking in the lessons. (Ai2)

> I would consider which approach is applicable.... After the first lesson, I would know about the pupils and would decide if I can use a certain approach. (Ii2)

Apart from concerns about preconceptions and increasing interactions in classes, other concerns about preparing for content, and practical activities (7) remained. However, the reliance on the textbook (5 to 3) and the heavy concern with content was lowered (7 to 4). As suggested in the above analysis, the concern for the content has thus become more diversified to include not only the teacher's knowledge but also pupils' ideas before the lesson and likely questions that pupils will raise. The student-teachers also had better ideas about how to teach or the possible teaching approaches that they may adopt. On the whole, it appears that the student-teachers shared considerations that were consistent based on a constructivist view of learning, as they reflected that they were concerned about pupils' preconceptions, that they would stimulate pupils to think, that they would attempt to relate science learning with pupils' experiences and that they would prepare for challenging questions from pupils. They were more knowledgeable about the possible teaching approaches to be adopted, and shared a wider view of science teaching that was no longer limited to conducting practical activities or teaching the textbook content.

5.4.2 Views about using various teaching strategies and activities in teaching science

The module aimed to prepare the student-teachers to teach science based on a constructivist view of learning. Apart from the concerns during lesson preparation, the choice of adopting various teaching strategies and activities in the science lessons may also suggest whether the student-teachers were influenced by the Curriculum Studies module and adopted a constructivist view of learning in their science teaching. The views about the choice of teaching strategies and activities which were collected from interviewing the thirteen student-teachers (Appendix A2, Section 3.3.2.1), and the quantitative part from questionnaires (Appendix C3, Section 3.3.3) responded to the whole group of student-teachers (39), are analysed and discussed.

5.4.2.1 Views collected from the qualitative part of the study

Before taking the module, science teaching was equated by the student-teachers with conducting practical activities, as shown by the large number of respondents (10 out of 13) noting these in their answers (Section 4.3.2). After taking the module, the student-teachers had a better understanding of the various approaches and diversified opinions about the approaches and teaching activities to adopt, as shown by the distribution of responses in Table 5f. A closer examination shows that the two most common mentioned approaches were discovery (11) or teaching science based on a constructivist view of learning (7), and at the same time some (6) considered adopting a mixture of the two approaches. The discovery approach was introduced earlier in the programme in another module in year one (the General Studies curriculum module) on the teaching of General Studies as a subject as a whole. The discovery approach that was introduced described a guided process through which learning experiences (in the form of activities) were arranged, and pupils had to think about their results and make their conclusions with the help of the teacher. For these (11) student-teachers, this was more familiar and may not have differed too much from teaching science based on a constructivist view of learning, as they interpreted them as both involving pupils in thinking actively. They may not have been aware of the difference in the basic assumptions of the two approaches about pupils' preconceptions, the social construction of meanings and the gradual changes in pupils' concepts. However, other student-teachers were found to have related the constructivist view of learning into their teaching, as they supported their choice by saying that they would consider pupils' preconceptions (3), adjust their teaching based on what pupils knew (3), and arrange activities to develop pupils' concepts (1). For example:

> I would consider what they think and see how that is related to the topic.... I would perform practical activities or use diagrams or videos or discussion. They can share their thoughts and see how others think. This may change their ideas. (Ci2)

Pupils' perconceptions, ways to stimulate thinking, and sharing of ideas were all seen as ways to change pupils' preconceptions.

Table 5f Student-teachers' comments on the application of the various teaching approaches before and after studying the module
(N=13)

Student-teachers' comments on the application of various teaching strategies/ approaches When you teach science, what are the most common strategies that you would employ? What are the principles in choosing these strategies?	**Occurrences before studying the module** $^{\Delta}$	**Occurrences after studying the module**
Choice of teaching strategies/ approaches		
Teaching science based on a constructivist view of learning*	0	7
Discovery approach	1	11
Adopt a mixture of discovery approach and teaching science based on a constructivist view of learning	0	6
Process approach	0	2
Teaching activities		
Practical activities	10	5
Discussion	4	1
Games/ other activities	2	3
Investigation after lessons	0	1
Activities to change pupils' concepts	0	1
Reasons for the choice of activities or teaching approaches		
To let pupils experience the process	1	0
To relate to current issues	1	0
To let pupils know what was happening	1	0
To match activities with the teaching objectives	1	0
Not to teach too in-depth knowledge	1	0
To engage pupils in thinking	2	2
To let pupils take a more active role in learning	0	1
To consider pupils' preconceptions	0	3
To consider what pupils know, and relate teaching content to their environment	0	3

$^{\Delta}$ Findings reported in Table 4c. * Not a defined approach but a range of strategies consistent with a constructivist view of learning.

Other reasons that were used to support the choice of teaching approaches and the teaching activities were also related to a constructivist view of learning. These included: aiming to engage pupils in thinking (2) and having pupils taking a more active role (1). These reasons were in sharp contrast with those given by the student-teachers before the module. Before the module, only two of the thirteen student-teachers mentioned engaging pupils in thinking by guiding them and letting them form their own ideas (Table 4c, Section 4.3.2). The above reasons related to a constructivist view of learning, and preconceptions were either not mentioned before or were mentioned at a very low occurrence. The student-teachers related how they would take into account pupils' thinking as they taught in the coming teaching practice:

> I would think about how pupils think. If they are wrong, I need to find out why they think in this way, or challenge them or correct them. It provides a reference for teaching. (Ei2)

Moreover, a student-teacher also summarized the change in her views about science teaching, which were consistent with a constructivist view of learning:

> The activities would emphasize on getting the pupils to find out and think. Science should not be taught or transmitted. Transmission is boring. Teaching science based on a constructivist view of learning emphasizes the pupils' preconceptions. Through the questions, there is communication with the pupils. The teacher can also correct the conceptions of the pupils. There is more room for pupils to think. (Why is this good for the pupils?) The pupils can relate the knowledge in science with other subjects. The pupils will have a high ability in analyzing and thinking..... I think this can be applied. I would try this in the teaching practice and more preparation will help, and I hope that I can master the approaches as soon as possible. (Gi2)

This quotation summarized the student-teachers' enthusiasm to try out the teaching approaches in the teaching practice and how this was motivated by her view about science teaching after the module. This may suggest that the Curriculum Studies module has influenced not only the actions to try using activities or questioning, but also the student-teachers' views that correspond more closely to a constructivist view of learning.

Despite the shifts in the constructivist view of teaching, the student-teachers highlighted a number of constraints (Table 5g). In considering which teaching approach to take for a particular class, the student-teachers suggested that the choice depended on the nature of the topic (1) as well as the learning style and ability of the pupils (2). They also voiced their concerns about not having sufficient background in science (2) and the possible difficulties of changing pupils' concepts (1). For example:

> Teaching science based on a constructivist view of learning is more desirable for me. I can tell whether pupils understand and their problems in learning. However, I am afraid that I do not have a sufficient background to teach based on a constructivist view of learning. (Bi2)

This suggests a concern about academic content knowledge and others (2) described how the interactions with the pupils may influence teaching science based on a constructivist view of learning:

> As there are many pupils in a class, it seems more difficult to teach based on a constructivist view of learning. It depends also on the motivation of the pupils. If the pupils are more active, it is good. In a class of thirty, for the pupils who are more active and out-spoken, they can learn more. For those that do not speak up, they just sit there and cannot learn much. Little interaction with the teacher can be achieved. (Ki2)

It therefore seems that the student-teachers were very much influenced by the reaction of their pupils in their teaching. They might lack the skill or the competence to motivate their pupils to share their ideas. This process may require more experience on the part of the teacher. Other perceived contextual constraints include the concerns about the tight teaching schedule (3), the diversity of pupils ideas (1), and pupils' not being active in class (1). Moreover, the student-teachers had a perception that teaching science based on a constructivist view of learning takes more time (2).

Table 5g Constraints perceived by the student-teachers in the choice of teaching strategies
(N=13)

Perceived constraints	**Occurrences in the interview data**
Time constraints	3
Teaching based on a constructivist view of learning takes up more teaching time	2
Large class size, little interaction, depends on pupils	2
Worry about having insufficient background in science	2
Choice of teaching approach depends on the nature of the topic	1
Choice of teaching approach depends on the learning style and ability of the pupils	2
What pupils know may vary a lot	1
It is difficult to change pupils' concepts	1
Pupils are not active in class	1

Before the module, the student-teachers tended to see science teaching as mostly concerned with conducting practical activities (Section 4.3.2). It appears from the findings that they had better knowledge of the various teaching approaches for science topics after the module and shifted towards having a constructivist view of learning (Table 5f). In actual practice, there were however, many other factors to consider besides their own knowledge of the teaching approach. These factors included their knowledge of the science content, the ability of the pupils, the nature of the topic, and the most common concern for primary teaching was the time available (Table 5g). The perceived influence of the ability of the pupils and the curriculum time available may be taken as sociocultural factors that may influence the culture of teaching and learning in the school.

5.4.2.2 Views collected from the quantitative part of the study

The views of the student-teachers (N=39) about science teaching were collected through the administration of a questionnaire before and after the Science Curriculum Studies module (Appendix C3, Section 3.3.3). There were three main questions in the questionnaire:

- the frequency of the teaching activities adopted in science lessons;
- the extent to which they agree with a number of statements about science teaching;
- a situation question that described a number of possible actions after having found out that pupils could not understand concepts about the properties of air.

The first two questions were structured on a five point Likert scale where a larger value represented higher frequency or stronger agreement. In the third question, the student-teachers were asked to rank order the possible actions. A paired sample t-test and a sign test were conducted to compare the two sets of responses concerning the views of science teaching among the student-teachers.

The same trend of difference was obtained from the paired sample t-test and the sign test (Table 5h), while the sign test indicated the direction of the change after the module. The directions of changes are summarized in Table 5i. Regarding the frequency of adopting the various teaching activities, the student-teachers rated pupils doing library research, and discussions led by the teacher or among the pupils in small groups to be more frequent after the module. Teaching activities such as checking workbooks and the teacher explaining the text were rated with lower frequency. They expected the pupils to assume a more active role in learning and hence they agreed more on asking pupils to do library research. They gave higher value to the discussions in the classroom. The choice of the teacher explaining the text in the lesson was rated as less frequent. These ratings may indicate a departure from the transmission approach and a shift towards the constructivist view of learning by acknowledging the importance of classroom interactions.

Table 5h Comparison of responses about the frequency of adoption of certain teaching activities and agreement with statements about teaching by paired-sample t-test

Teaching activity or statement	**Mean before studying the module N=39**	**S.D.**	**Mean after studying the module N=36**	**S.D.**	**P value by sign test**	**P value by t-test**
Teacher led discussion	3.61	0.84	3.97	0.56	0.049*	0.014*
Pupils discussing in small groups	3.47	0.77	3.92	0.60	0.027*	0.014*
Pupils doing library research	2.54	1.04	3.23	0.94	0.043*	0.006 ***
Teacher explaining the text	3.56	1.18	3.03	0.81	n.s.	0.013*
Teacher checking workbooks with pupils	3.49	1.02	3.08	1.02	0.035*	n.s.
My previous learning experiences in the secondary and the primary school science have strongly influenced my teaching. (constructivist view)	3.22	1.02	3.58	0.73	n.s.	0.051*
It's no good just letting pupils discuss their ideas among themselves. They tend to focus on the unimportant and the irrelevant. (against constructivist view)	3.28	1.00	2.47	0.84	0.000 ***	0.000 ***
I should provide pupils with good structured explanations of the text and workbooks for each topic, something they can revise at home and learn. (transmission view)	3.86	0.42	3.53	0.74	0.049*	0.016*

P<0.05 * p<0.01** p<0.005***, n.s. not significant at p=0.05

Table 5i Results of the sign test about the frequency of adopting various teaching activities and agreement with statements about teaching

The frequency of adopting various teaching activities **Items that showed an increase in frequency after the module:** Teacher led discussion * Pupils discussing in small groups * Pupils doing library research ** **Items that showed a decrease in frequency after the module:** Teacher checking workbooks with pupils * Teacher explaining the text (decrease from quite often in every lesson to sometimes) *
Statements about teaching **Statements that shifted from agree and strongly agree to disagree** Its no good just letting pupils discuss their ideas among themselves. They tend to focus on the unimportant and the irrelevant. (against constructivist view) *** I should provide pupils with good structured explanations of the text and workbooks for each topic, something they can revise at home and learn. (transmission view) * **Statement that shifted from strongly disagree and not agree to no opinion and agree** My previous learning experiences in secondary and primary school science have strongly influenced my teaching. (constructivist view) *

$p < 0.05$ * $p < 0.01$ ** $p < 0.005$ ***

Student-teachers' responses to three of the thirteen statements showed a significant difference in the ratings after the module. The student-teachers agreed more with the importance of previous learning experiences influencing their teaching. They agreed less with the statements that discussions are not important and that teachers should provide pupils with good structured explanations of the text and workbooks, which are regarded as being contrary to the constructivist view and in agreement with the transmission approach.

These patterns of the frequency of teaching activities and the agreement with statements about science teaching were consistent with each other. The student-teachers accorded higher value to discussions with pupils, pupil-pupil discussions and pupils taking an active role in learning than with teacher explanation. Moreover, they also indicated that they agreed more with statements that reflected the influence of their past learning experience on their teaching.

Apart from the two questions above (rating the frequency of the teaching activities and the extent of agreement with a number of statements), the student-teachers were also presented with a situation question in order to identify the changes in their views about science teaching (Appendix C3, Chapter 3 Section 3.3.3). The situation question about science teaching read as follows:

> You have taught a topic on air to a class of primary 4 pupils. At the end of the topic, you find out that your pupils think that:
> air is weightless
> water droplets that condense on the surface of a can of soft drink come from the inside of the can.
> What would you do in the next lesson?

However, the response from the situation questions did not provide further or different information from the other two questions above. Hence, the results are not presented or discussed here.

On the whole, the quantitative and the qualitative findings were in agreement, suggesting that the student-teachers had shifted more towards a constructivist view of learning.

5.4.2 Summary

In summary, the above discussion described the changes in the views of the student teachers in terms of their concerns during lesson preparation and their views on the adoption of teaching strategies and approaches. The changes in the views about teaching among the student-teachers provides a picture of how the Curriculum Studies module might have influenced them, as well as the resulting development or learning.

It appears from the data that the Curriculum Studies module has influenced the student-teachers to adopt a constructivist view of learning. The findings in the interviews with the thirteen teachers suggested that during lesson preparation, the student-teachers would give more consideration to pupils' preconceptions and stimulating pupils to think. They shared more diverse concerns than just focusing on the content and conducting practical activities as compared with before they completed the module. Regarding the teaching strategies, they were more ready to try out the various teaching approaches, though they related more about the discovery approach and teaching science based on a constructivist view of learning. Their choice of teaching strategies as reported in the interviews were made mainly based on a constructivist view of learning, as they emphasized an active role in learning, the importance of getting pupils to think, considering pupils' preconceptions, and attempting to relate their teaching with pupils' experience. The quantitative data supported the findings in the qualitative part. The emphasis on classroom discussions was prominent after the completion of the module.

Apart from the apparent shift to a constructivist view of learning, the student-teachers described a number of sociocultural factors that may influence the school culture. They were conscious of the practical or contextual constraints that they may face in schools, such as the limited time available and the large class size. They worried about getting sufficient interaction with pupils, showing their concern for effecting quality classroom discussions. These may be taken as sociocultural factors that determine the school culture which may in turn influence the classroom teaching of the student-teachers.

5.5 Feelings about teaching science based on a constructivist view of learning

The changes in the feelings about teaching science with a constructivist view of learning among the student-teachers before and after the module may be taken as the personal development of the student-teachers. This may also provide a basis for predicting how likely the student-teachers may be able to adopt science teaching based on a constructivist view of learning in the future. The responses to the question were summarized and compared with those collected before the Curriculum Studies module:

- How do you view yourself learning to teach science?
- How do you feel about having to teach science topics with a constructivist view of learning?

Before taking the Curriculum Studies module, the thirteen student-teachers shared a lot of negative feelings about teaching science in General Studies as in their interviews (Table 4.5) negative feelings were mentioned 16 times, while positive feelings were mentioned only twice (Table 4h). Their worries included both content and pedagogy. Though most of them lacked positive experiences in learning science in their previous education, the concern for providing a "different" learning experience for their pupils was raised. After taking the module, the feeling was mixed and diversified (Table 5j). There were thirteen positive comments and among them four student-teachers shared positive feelings about finding out pupils' preconceptions, and six found it helpful to know pupils' preconceptions. For example:

> I agree with the point that pupils know something before the lesson. There should be a gradual change in pupils' science concepts. Finding out what pupils know is helpful. I can teach or start from what they are interested in. I can also find out their wrong concepts and correct them. The teacher needs to do more preparation and be aware of pupils' interests and lives. This is worthwhile. Understanding what pupils think and are concerned about is helpful in creating a lively learning atmosphere. To know what the pupils think is interesting in itself and I am not doing it only for the job. (Ei2)
>
> The teacher can also know more about the pupils and know if they understand the topic, unlike the transmission approach. The work of the teacher is worthwhile. You can tell if the pupils understand or not during the lessons. You don't need to wait until exams to know if you have taught effectively. (Bi2)

These student-teachers noted that it was a worthwhile task to identify pupils' preconceptions (1) and could appreciate the interest in doing so (1). They saw teaching as getting pupils to understand as well as trying to understand pupils' thinking.

> It is difficult to find out pupils' conceptions. It is time consuming and takes time to teach. However, it is good and can help to develop relationships with pupils. Pupils have some form of scientific knowledge in their daily life. I would try the approach and would make use of the time during recess to find out their preconceptions. Understanding what they know will also save time during the lesson. I would try this approach. (Ci2)
>
> The emphasis is on thinking about how the pupils think. Before I would have considered more about how the teacher teaches. I have one more consideration now: how do the pupils think? I consider their thinking or ability level, how their knowledge or concepts are

developed. I have the confidence to teach with that approach. However, I haven't tried this before, I may try this in the teaching practice. (Ii2)

The student-teachers making the above positive comments defined teaching as trying to relate what pupils know from their daily life experience and helping pupils to develop their concepts from what they know. These considerations are congruent with a constructivist view of learning. They also come to analyse teaching from a new perspective, that is from teacher teaching to getting pupils to think. The task was described as a difficult but worthwhile one.

Table 5j Student-teachers' feelings about teaching science based on a constructivist view of learning after studying the module.
(N=13)

Feelings about teaching science based on a constructivist view of learning as perceived by the student-teachers (How do you feel about having to teach science topics based on a constructivist view of learning?)	**Occurrences after studying the module**
Positive feelings	
Helpful to know pupils' preconceptions in teaching	6
Having confidence to teach through a constructivist view of learning	2
Worthwhile attempt but would be difficult	1
Difficult but workable	1
This belief coincides with own belief in teaching	1
Have more considerations in teaching	1
Pupils can achieve genuine understanding	1
Concerns or considerations for implementation	
Hard to change pupils' preconceptions	3
Hard to consider preconceptions of individual pupils	1
Difficult to understand the philosophy behind it	1
Difficult to implement	3
Spend more time to prepare for lessons	2
Takes more time to teach	1
Nervous about putting it into practice	1
Lack practical effectiveness	1
Neutral comments or feelings	
Observe the pupils before deciding the approach to take/depend on the situation/topic	4
Would try different approaches	3
Would need to read about the approaches	2
Haven't seen past teachers teaching with the same approach before	1
Takes time to develop competence	1
Change in pupils' concepts depends on whether the teacher has clear concepts	1

Although there were positive comments, the student-teachers raised a number of concerns (thirteen comments were made) about teaching based on a constructivist view of learning in classrooms. These include finding it hard to change pupils' preconceptions (3), the time needed to develop competence in teaching science (1), the teacher's concept in the subject (1), and not having experienced learning with that approach as a student in school (1). These feelings were described by the student-teachers. For example:

> I would find out pupils' experience through questioning in class. Then I would follow up on these. In the lesson, I would perform practical activities. I would try to change their concepts. But this may be difficult. The pupils may follow you and put down the correct answer. However, in their thoughts they may still persist in their own belief. This is more difficult if we have to change that. (Li2)

The student-teacher in this case was concerned about changing the pupils' ideas.

> It (teaching based on a constructivist view of learning) means more work but is not too difficult... In the teaching practice and the first year it may not be very good, but I have the confidence to use it. This may however, take more time e.g. one year. (Di2)

Though it may mean more preparation, this student-teacher related her confidence to teach.

> I have seen how my teachers taught using the discovery and the process approach; I have memories of those lessons. For teaching science based on a constructivist view of learning, I have not learnt in that way before and it is less familiar to me. The trying out in the module is not sufficient. I haven't seen how pupils learn in that way and the classroom situation may influence the effectiveness of the approach... When we have to catch up with the teaching schedule, it would be risky. (Ki2)

Moreover, this student-teacher was concerned about having prior learning experiences with teachers who taught based on a constructivist view of learning. In making this comment, the student-teacher was trying to relate the personal learning experience as a student with his classroom practice.

The above concerns are interpreted as practical considerations about putting into practice what the student-teachers have learnt in the module. They considered pupils' ideas, thought of how to represent abstract ideas and were also aware of the difficulties for these changes in their teaching to occur. From these considerations, it appears that the student-teachers not only had the theoretical understanding of the teaching approaches but also came to consider the practical implications of such practice in the classroom. Realizing the practical difficulties and the importance of teaching experience can also be taken as a measure of positive professional development. It appears that the experience of taking the module has developed among the student-teachers positive feelings in learning and has influenced them to reflect on their own learning experiences and science teaching.

5.6 Summary

It appears from the findings that the student-teachers had shifted towards a constructivist view of learning. In the Curriculum Studies module, the student-teachers compared their learning with that of the pupils. The experience of learning through the different approaches themselves helped them to conclude the implications of each on teaching and learning in the primary classroom. They identified the implications of the constructivist view of learning in their teaching as engaging pupils in thinking, clarifying pupils' concepts, and continuous self-learning. They indicated the importance of discussions, teacher-pupil interactions and pupil-pupil interactions in the learning process. Regarding the choice of teaching strategies, the student-teachers made their considerations based on a constructivist view of learning emphasizing engaging pupils in thinking, considering their preconceptions, and relating the content with daily life experiences. It may be assumed that the learning in the Curriculum Studies module has influenced their views about learning and teaching science. Learning science was not regarded only as learning the content knowledge, but was taken as engaging pupils in thinking, developing an increased awareness in developing process skills, nurturing an interest in science, and equipping pupils for continuous learning. These changes in views of science learning and teaching which matches a constructivist view of learning may be taken as the professional development of the student-teachers.

Despite the awareness of considering teaching from a constructivist view of learning, the student-teachers still held a belief that the examination subjects are more important than science in the primary curriculum. This is not surprising given that achievements in the subjects Chinese, mathematics and English have a significant bearing on the secondary school places allocation system and are widely accepted by parents and primary teachers as more important. Although the majority of the interviewees held positive views about the influences of the constructivist view of learning in science teaching, there were concerns about the limitation of time and the lack of responses from the pupils. These may be taken as sociocultural factors in the school context that may influence the views of teaching and learning science among the student-teachers.

Feelings of confidence in science teaching may be taken as positive personal development. The feelings towards teaching science were more positive when compared with those held by the student-teachers before the module. It may be interpreted as the influence of the Curriculum Studies module that helped them to develop better confidence in teaching science. Though it appears that the Curriculum Studies module has influenced the student-teachers to develop professionally and personally, the student-teachers expected a number of difficulties in teaching science based on a constructivist view of learning in the primary classroom.

Chapter 6

The student teaching experience

6.1 Introduction

This chapter describes the professional, social and personal development of the student-teachers during their teaching practice experience. The teaching practice of eight weeks took place after the Curriculum Studies module was completed and this was the second teaching practice for the student-teachers in the teacher education programme. Among the thirteen student-teachers who were involved in the previous rounds of interviews, eleven of them had a chance to teach a science topic in their teaching practice, which took around two weeks to complete. The qualitative data documented in this chapter comes from the interviews (Appendix A3, Chapter 3, Section 3.3.2.1) and lesson observations with these students. The quantitative results reported in this chapter include the data collected from the questionnaire for all the 39 student-teachers who took the Curriculum Studies module, as in Appendices C2 and C4 (Chapter 3, Section 3.3.3).

The discussion in this chapter documents the student-teachers' experiences of teaching science in the classrooms, the problems or influences that they experienced, and their feelings about teaching science in school.

6.2 Teaching science with a constructivist view of learning during the teaching practice period

This section describes how the student-teachers taught science, based on a constructivist view of learning, in schools. The eleven student-teachers who taught science topics were interviewed and asked the following questions:

> How did you actually go about teaching science topics in the teaching practice?
> Tell about: the preparation, the activities you employed, the principles behind them, classroom management, assessing pupils' learning and if there were any really successful lessons that you remember.

The findings in the following sub-sections draw on the responses to these questions and are grouped as:

- how the student-teachers planned their science lessons,
- what teaching strategies they employed,
- the lessons that they conducted, and
- their perceived influence of the constructivist view of learning on teaching.

6.2.1 Concerns and strategies during lesson preparation

The concerns of the student-teachers during their teaching practice period differed from the time when they were at the Institute. Before they took the module, the main concerns were those about the content to be taught, and designing activities (Section 4.3.1). There was a shift after they took the module - a range of concerns based on a constructivist view of learning were raised at the time after the module (Section 5.4.1). When it came to the teaching practice, the focus moved to a range of practical concerns about time (2)[1], classroom management (3), safety (3), the ability of the pupils (6), providing opportunities for pupils to learn from each other (1) and reading the module notes (1), none of which appeared in the previous interviews. For example:

> I consider the pupils' ability level for this class. The worksheets cannot be too difficult though some are easy and they should know. However, sometimes they don't even know the basics. Their interest. It is hard to arouse their interest. It is hard to design an activity that arouses their interest; their interest in learning is low. (Di3) (see Chapter 3, section 3.4.2 for a description of the coding)

These considerations suggest that the student-teachers were trying to relate what they learnt about teaching in the Institute with the school context. Table 6a provides a summary of the concerns that were raised before and after the Curriculum Studies module, and during the teaching practice. Consistent with a sociocultural view of learning, the student-teachers suggested the importance of interactions or consultation with peers, lecturers and supervising teachers (11) during the teaching practice. For example they mentioned:

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[1] The number in brackets represents the number of student-teachers mentioning this in the interviews.

I asked my classmates the learning of their pupils, their progress and how much their pupils can achieve. (Bi3)

I asked the classmates who have taught the same topic and shared with them my experiences of teaching the same topic, in conducting the activities. (Ci3)

I discussed with my friends about the teaching activities. I have seen the activities that other students designed. I improved on their design e.g. the practical activity on light and shadow. (Ei3)

Table 6a Strategies for preparing lessons as reported by the student-teachers in the first three interviews
(N=11)

Strategies for preparing science lessons	**Occurrences before studying the module** [Δ]	**Occurrences after studying the module** [♦]	**Occurrences during teaching practice**
Consult supervising teachers/lecturers/peers	2	0	11
Design own topic sequence	0	0	1
Consider what pupils have learnt before	1	5	4
Think of ways to attract pupils' attention	1	2	4
Collect information about the topic	0	3	3
Prepare teaching aids	4	1	4
Consider the aims, and design appropriate activities or practical activities	8	7	3
Try out practical activities	1	3	1
Stimulate pupils to think in lessons or Ask thought-provoking questions	0	1	0
Stimulate pupils to recall their own experiences	0	1	0
Reflection on different teaching approaches	0	4	0
Design worksheets/questions	1	0	0
Prepare for challenging questions from pupils	1	2	0
Study the content and be clear about the topics to be taught	5	3	0
Read up the content / Consider the content to be taught	7	4	0
Relate content to daily life experiences	1	0	0

[Δ] Findings reported in Table 4b.
[♦] Findings reported in Table 5e.

I have discussed it (my teaching) with my classmates who have taught the same topic. We discussed the content and the activity as well. (Gi3)

I have to try them (the activities) out at home and ask my classmates to see if they work out in their classes. (Mi3)

We discussed the content, about what can be added and what the pupils would want to know more about as well as the activities. (Ki3)

The theme of the discussions ranged from the teaching content, the activities, and pupils' interest and ability. For learning science in the classroom, one of the student-teachers mentioned how opportunities were provided for pupils to learn from each other.

> I have discussions. I hope that the pupils can learn from each other. They can argue and know about how others think. (Ii3)

It appears that this student-teacher valued the importance of interactions both in their own learning and in their pupils' learning.

The concern for the content to be taught was reflected as the student-teachers talked about collecting information on the topic. From the fact that none reported reading the teachers' guide, the reliance on the textbook and the teachers' guide is weaker than the time during the Curriculum Studies module. One of the student-teachers had even designed his own topic sequence in teaching:

> I consider which are the basic concepts and gradually add in more difficult concepts. I design my own sequence of teaching and it may be different from the textbook. (Gi3)

Based on the researcher's previous experience as a teacher educator, it would appear that these practices are quite rare, if not non-existent, among the student-teachers who had a weak science background. There was, however, a slight decrease in consideration about asking thought-provoking questions, stimulating pupils to recall their own experience, reflecting on the teaching approaches, and preparing for pupils' questions. These may be interpreted as more detailed considerations that the student-teachers did not focus on while they were still trying to adapt their science teaching to the classroom situation.

On the whole, the scenario was different from the time before they took the module when they talked about reading up textbooks and teachers guide for the main source of information instead of collecting information themselves. It appears that the Curriculum Studies module has influenced the student-teachers to take a constructivist view of learning as they suggested that their considerations were made based on the ability of the pupils and what they have learnt, and the importance of interactions in their own learning and the pupils' learning.

6.2.2 Teaching Strategies that were employed by the student-teachers

In the interviews during the teaching practice, the student-teachers (11) were asked to describe the teaching strategies that they used. There were attempts to find out pupils' preconceptions before they taught the topic (9). A variety of ways were used to achieve this purpose (Table 6b). Raising questions in previous lessons was one of the ways (4). For example:

> I asked them (the pupils) if they are aware that when they play under the sun, there are black objects following them. Some of them tell the word "shadow", some cannot. (Bi3)
>
> I do this at the start of every lesson. For example, I asked them if they know about the attempts to protect the environment in Hong Kong before the next topic on environment. (Hi3)

Table 6b Ways that the student-teachers elicited pupils' preconceptions (N=11)

	Occurrences in the interviews
Ways to elicit pupils' preconceptions	
Questions raised in previous lesson	4
Questions raised in lessons of other subjects	1
Check pupils' understanding by asking them to fill in worksheets	2
By observing what pupils play with	1
Ask pupils to collect pictures on a certain topic	1
Based on studies of pupils' preconceptions	1
Implications of knowing pupils' preconceptions	
Adjust teaching with a knowledge of pupils' preconceptions	7
Supplement what pupils don't know with examples	1
Provide counter examples to make pupils realize wrong concepts	1
Teach something not in the textbook	2
Spend more time on difficult parts	2
Constraints in the process of finding out pupils' preconceptions	
Pupils have low ability or time constraints	3
Would find out pupils' preconceptions in full-time teaching	1

Another student-teacher described how he tried to find out how pupils think about a certain topic through a discussion of the related topic in a different subject lesson:

> I have taught the same class Chinese. In those lessons, I have asked the pupils what they think insects are and how much they

> know about flowers. I also asked them how animals reproduce. I found out that they know about viviparous and oviparous but they know nothing about internal or external fertilisation. (Ci3)

Student-teacher I was given a class in which the teaching of the topic always lagged behind the Educational Television Programme (ETV)[2]. The pupils would thus have heard more about the topic before they started the lessons. The student-teacher hence checked the understandings of the pupils after they had watched the Education Television programme.

Asking pupils to collect materials before the lesson was also employed in order to find out pupils' preconceptions:

> For example, I have asked them to collect pictures of animals and plants before the topic on reproduction. They would then group the pictures by the different ways of reproduction. (Li3)

Two other teachers used more indirect ways to obtain a picture of the pupils' preconceptions. One of them (E) related that he was more aware of the children's environment and the toys they had. Another (M) referred to research findings about children's science ideas, such as:

> I made reference to the materials you provided about pupils' preconceptions on the topic heat. (One of the reference readings in the Curriculum Studies module discussed how children think about the concept of heat and the sources of heat.) (Was there any influence on the content you chose?) Yes, I thought of more activities after reading that, otherwise there were not many activities in the book....I also reconsidered the sequence of topics to be taught. For example, there is a practical activity on conduction using rods made of different materials. This is to let pupils distinguish between materials that are good and poor conductors. Before doing this, I used another demonstration to show the transfer of heat in a metal rod. This is a different activity using butter. I prefer to teach one concept at a time and not mix up the two. (Is there any relationship with what you know about pupils' preconceptions?) I think about how to arrange the topics in the following lessons, using the information on pupils' preconceptions as a reference. (Mi3)

[2] The Educational Television programmes (ETV) are specially prepared for each topic and cover most of the content for the subjects Chinese, English, mathematics and General Studies. It may include demonstration of practical activities or other information related to the topic. Most schools arrange for the pupils to have the lessons before they watch the ETV and used it as a summary of the topic.

One of the student-teachers found it difficult to find out pupils' preconceptions and suggested that this may be more feasible after she began to teach as a full-time teacher.

> There is not much chance to talk to the pupils. I don't have other opportunities to talk to the pupils. If I am really teaching in the school, I may try this. In the teaching practice, there is very little time available. (Ji3)

Checking pupils' preconceptions is one of the ways that shows how far the student-teachers identified their teaching with the constructivist view of learning. The student-teachers were generally aware of the importance of knowing how their pupils think before the lessons. They have tried various ways to find out their ideas. However, as they were student teaching, their contact with the pupils was limited and this situation may vary after they start their first teaching position.

Having found out the pupils' preconceptions (7), the student-teachers reported that they adjusted their teaching with respect to what the pupils knew. For example:

> I check their understandings on the basics before I go into other topics. Hence, I may not follow the timing in the lesson plan; I react more to pupils' reaction. I think the time is only for reference. I cannot proceed to another part before pupils really understand the basic parts. Sometimes, pupils have questions; I make use of their questions and have more in-depth discussions on the topic. Their questions mean that they are interested in the particular area. This also means that they have been more attentive in the lesson. There will be less class discipline problems. (Ki3)

Questions from the pupils provided a basis for further discussions of the topic.

> I do this at the start of every lesson. I have tried. For example, I asked them if they know about the environmental attempts in Hong Kong before the next topic on the environment. I considered how much they know and how much the textbook requires, then I teach the difference between these. If they know more, I skip the basics. I spend more time on the difficult parts. (Hi3)

This student-teacher adjusted the amount of content to be taught and used the time for the difficult ideas. Another adjustment involved modifying the topic sequence based on the information about the children's preconceptions:

> There are some similarities between the pupils in my class and

> those in the study (information about children's conceptions of science are provided in the Curriculum Studies module). I reconsider the sequence of topics to be taught.... I think about how to arrange the topics in the following lessons, I use the study on preconceptions as a reference. (Mi3)

Having realized the pupils' preconceptions, teacher E related how he had supported his teaching with counter examples:

> They must have used or played with magnets and know what they are. They may not know what the materials are that the magnets can attract and what the shiny materials are that are attracted. I tried to find some examples that are not attracted by magnets but are shiny so that they know it is metals that are attracted by magnets. (Ei3)

These student-teachers adjusted the content to be taught by allowing the discussion to be more in-depth, to be more adapted to the needs of the pupils, to rearrange the topic sequence, and to allow the timing of the lessons to be more flexible. These were different from "typical" practices in which the teachers taught most of the content following the textbook and were trying to catch up with a set teaching schedule.

Four of the student-teachers reported that they did experience certain constraints in finding out pupils' preconceptions:

> I have asked them to collect information before the lesson...However, the quality was poor. These (pupils' preconceptions) do not have any influence on my teaching. They don't know how to ask questions. Unlike the brighter class, they have a lot to ask. They (this class) know very little about the topic and I teach only the basics. (Li3)

The time constraints and the ability of the pupils influenced the student-teachers in attempting to find out pupils' preconceptions.

Another strategy that was consistent with a constructivist view of learning was to help pupils to apply the concepts learnt (Table 6c). This was raised by ten of the eleven student-teachers. The strategies included getting pupils to be more aware of their daily life experiences (4). For example:

> The pupils will apply these in their daily life experiences, there are kettles at home, and they have to hold their cups. I can ask them to observe things around them...(Ji3)

Pupils' discussing what they have learnt with people around them was taken as a form of applying the new concepts (1). For example:

> They (the pupils) can be more aware of the news on space explorations, etc. They would be interested to know and learn about how the earth moves. This can be applied as they talk to their classmates and their parents...They will talk about this in their daily conversations. (Ii3)

Moreover, the student-teachers presented problems for pupils to solve in getting them to apply the newly learnt concepts (2), such as:

> In the topic magnetism, there is a sub-topic on the application of magnetism. ... In one of the activities, I pretended that I had dropped all the paper clips on the floor and asked the pupils how I could pick them up. Some of the pupils were able to apply the theory of magnetism and use a magnet to attract them. (Bi3)

Table 6c Ways that student-teachers employed to allow their pupils to apply the concepts learnt in the lesson
(N=11)

	Occurrences in the interviews
Ways to let pupils apply concepts learnt	
Ask pupils to complete a worksheet	4
Pupils are more aware about the news and what happens around them	4
To solve a problem	2
Conduct an activity after the lesson	2
Conduct a short quiz	1
Ask the pupils to distinguish between examples	1
Ask pupils to design toys and games	1
Pupils would talk about what they learnt in their daily conversations	1
Ask pupils to give examples	1
Limitations	
Pupils with low ability and are reluctant to think	1
Problem with basic concepts learnt before	1

The concept of applying newly learnt ideas among the student-teachers was therefore not only limited to within classroom situations but could also be applied in the pupils' daily conversations and in explaining what happened in their daily life experiences. The student-teachers were also keen to provide opportunities for them to apply the ideas in the classroom through activities (2), presenting problems (2), and worksheets (4).

The student-teachers valued the preconceptions held by the pupils in their teaching and were ready to adjust their teaching according to the needs of the pupils. These included attempts to re-arrange the topic sequence, spending more time on difficult concepts, teaching beyond the textbook context and being more flexible in timing the lessons. These attempts made them different from the practice of most of the primary teachers that they have experienced in their past education experience when the utmost concern was to complete the topic within the scheduled time. Applying the concepts learnt was also emphasized by the student-teachers who defined application as not only limited to answering questions on worksheets but also getting the pupils to put what they had learnt into their daily life experiences. In terms of their professional development in teaching science, it appears that they have adopted a constructivist view of learning in their science teaching. The development of this view may be interpreted as an influence of the Curriculum Studies module.

6.2.3 Teaching science in the primary classrooms – the lesson observations

During the teaching practice, the researcher observed the teaching of the eleven student-teachers in the schools in order to obtain an understanding of what their science lessons were like, to what extent they teach science based on a constructivist view of learning, and the influences on their teaching. Every student-teacher was observed once for a lesson that ranged from 35 to 40 minutes. The findings in this section were obtained from the transcription of the lessons and the researcher's field notes. The student-teachers volunteered their teachings to be observed and these observations did not contribute to the assessment of the teaching practice.

6.2.3.1 Helping Conceptual Change

A list of teaching actions that is congruent with the constructivist view of learning was drawn up in order to analyse to what extent the student-teachers were able to teach science based on a constructivist view of learning. The list is based on one developed during a research project that helped teachers to teach science with a constructivist view of learning (Bell, 1993). The actions were chosen on the basis that they characterize science teaching based on a constructivist view of learning and that they differed significantly from "typical" science lessons in Hong Kong (Chapter 1 Section 1.2.1). These also have to be actions that were observable during the lessons. The planning and other teacher actions, such as eliciting pupils' preconceptions, that were not observable in a single lesson were described and analysed in the previous sections 6.2.1 and 6.2.2.

Based on a constructivist view of learning, the nine teacher actions that may help pupils' science learning are (section 2.3.1):

i. Presenting questions for pupils
ii. Inviting pupils to ask questions
iii. Asking pupils to predict results of practical activities
iv. Illustrating by using a range of examples
v. Illustrating by using practical activities
vi. Relating new ideas with previous concepts
vii. Using the newly learnt ideas in new situations
viii. Pupil initiated activity
ix. Clarifying pupils' ideas by using other examples

The following sub-sections describe the nature of each of the teaching actions with illustrations from the lesson observations and field notes.

(i) Presenting questions for pupils

All the student-teachers attempted questioning as a way of getting pupils to think about the topics as well as further developing their concepts. Questions were presented in various forms. Four of the student-teachers had the questions written down on a worksheet that guided pupils' group discussion. For example:

> The student-teacher provided pictures and worksheets to guide the discussion. Each picture represented a cause of water pollution. The themes of the pictures included: sea pollution by reclamation, domestic waste, oil leakage; fresh water pollution by chemicals, farm waste. Beneath the pictures were questions asking pupils to suggest the cause of the pollution, the influence and the prevention. (Don 6) (see Chapter 3, section 3.4.2 for a description of the coding)
>
> The student-teacher provided each group of pupils with a set of word cards and a comparison table and asked them to match into the table the characteristics of wind, insect and self dispersed seeds. The student-teacher reminded the pupils to close their textbooks as they completed the table. She encouraged the pupils to put in as much as they knew. After the activity, the pupils were asked to describe the characteristics of the seeds and relate that with the method of dispersal. (Lon 5)
>
> T: Can you describe one characteristic for wind dispersal?
> P: Having wings
> T: Can you give an example?
> P: pine seed.
> T: (Showed a diagram of the pine seed) Is there any other characteristics?
> P: light
> T: Most of wind dispersed seeds are a lot lighter and are easily blown by wind. Are there any other characteristics?
> P: (the same pupil above cannot answer the question, the teacher asked again, another pupil volunteered). Hairy.
> T: Can you give an example?
> P: Dandelion.
> T: (Showed a diagram of the plant in a library book) What does the hair look like?
> P: Parachute.
> T: These seeds are light and easily blown by wind. Are there any other characteristics? (The teacher showed another picture of the "wooden cotton flower" also commonly found in Hong Kong.)
> P: There are fibres.
> The teacher agreed and asked the pupils to conclude on the characteristics of wind dispersal. (Lo 5)

In other lessons, questions were asked after teacher demonstrations (3 out of 11 lessons observed). Pupils were asked to report their observations and make conclusions about the findings or implications of the demonstrations. For example:

> The student-teacher used a wooden stick to beat a can with different degrees of strength and asked the pupils (Primary 1) to describe the sound produced. The demonstration was repeated using a pair of chopsticks and the pupils were asked to describe the sound. The teacher next asked the pupils to relate the volume of sound produced with the degree of strength used in beating the can. (Eon 1)

> In another, the demonstrated practical activity was the expansion of a metal ball which could not pass through a metal ring after heating. After putting the metal ball into cold water, the metal ball contracted and could pass through the ring. The teacher asked the pupils to explain their observations. (Jon 2)
>
> The student-teacher showed the class two spoons, one with a metal handle, the other with a plastic handle. She then asked the pupils to tell the difference between the two spoons. The pupils named the differences. (The previous lesson was on good and poor conductors of heat). She asked the pupils why there was such a difference. She then put the two spoons into hot water. During the waiting time, the teacher asked the pupils to predict the results.
> P: one is hot and one is not.
> T: Which is which?
> P: The one with plastic handle is not hot and the other is hot.
> The teacher invited the pupils to try the hotness of the spoons. The pupils reported their feelings about the hotness. Next the teacher asked the pupils to explain their observations. (Mo 2)

In two other situations, the student-teachers arranged an activity for the pupils during the process or at the end of which they raised questions to help pupils to develop their concepts. For example:

> The student-teacher invited the pupils to participate in an activity about whether light could pass through certain objects. The student-teacher placed the objects (which included books, transparent plastic cups, overhead transparencies, etc.) onto the overhead projector. Before the student-teacher placed a certain object on the overhead projector, the pupils were asked each time to predict whether light could pass through and put down their prediction on the worksheet. The predictions of the pupils were mostly correct. The student-teacher then asked the pupils to list the common characteristics of the objects that allow light to pass through and helped pupils to develop their understanding of transparency. (Bon 1)
>
> The pupils brought their own fruit for the activity. Their task was to cut the fruit into halves and observe the characteristics. The pupils then completed a table on the blackboard put up to summarise the findings of the different groups. Following the activity, the student-teacher raised a series of questions about the functions of the fruit.
> T: Why do the flowers not directly develop just into seeds? Why are there the fruits?
> P: They protect the seeds. The monkeys will eat the fruit and spit out the seeds or the seeds will go out with the faeces of the animals. (Ko 5)

Questions were also raised during teacher led discussion with the whole class of pupils. For example:

The student-teacher conducted a discussion with the pupils about the structure and functions of the flower.
T: What is the function of the female reproductive part of the flower (pointing to a diagram to show which part he is referring to).
P: To absorb nutrients.
(Other pupils said from their seats that this is wrong.)
T: Where will the pollen from another flower land? Why was the pollen held and not blown away again?
P: The stigma receives the pollen grain. There is sticky liquid on the stigma.
T: Touch the stigma and feel it. How does it feel?
P: Sticky.
T: Where will the pollen go after this?
P: Go into the style.
T: So what is the style like?
P: Hollow.
The student-teacher asked the pupils to look at how the stigmas, style and ovary are organised in the flower. (Co 5)

The discussion was about the shape of the earth. The pupils had watched an Educational Television programme on the topic before the lesson.
T: What is the length of the equator?
P: 3.1416 divided by 2
(Other pupils asked why.)
T: Why did you say this?
P: I don't know.
T: The length is actually 40,075km. What is the shape of the earth?
P: It is almost spherical.
The student-teacher asked the pupils to show their hands if they agree the earth is a sphere or not. Half of the class agreed that it is a sphere and half do not.
The student-teacher then drew a line perpendicular from the north pole to the equator and asked the pupils to compare the half length of the line and that of the equator.
T: What do you think the lengths will show?
P: If they are equal, then it is a circle.
The student-teacher asked the pupils to raise their hands to show which side they think is longer. Most of the pupils showed that the half equator is longer.
The student-teacher provided the length 6,378km and 6,357km suggesting that the difference is 20km.
T: Is the earth a sphere?
P: No. It is flattened. (Lo 4)

Presenting questions is the most common strategy for the student-teachers to get pupils thinking. The use of worksheets has been useful in group work. The pupils were also asked to predict the results of the practical activities. This maximizes the opportunity for the pupils to think, and compare what they think with the results of the practical activity. Questions were also raised during class discussions when the student-teacher presented a question for the whole class of pupils to think about.

(ii) Inviting pupils to ask questions

Three of the lessons observed included having the student-teacher inviting pupils to ask questions. For example,

> During a lesson on flower structure, pupils asked the student-teacher about the details of the structures of daffodils and the Christmas flower. (Con 5)
>
> After a discussion on the various causes of water pollution, a pupil came up with a question, "If someone jumped into the sea, is this water pollution?" The student-teacher answered, "It is hard to define. If the material causes some deterioration of the water quality, we regard that as water pollution. If you swim, that should not be regarded as water pollution." (Don 6)
>
> In a lesson on the structure of fruits, a number of questions were raised by the pupils, which included:
> How do we classify the structure of the coconut? How do they disperse the seeds?
> Do we need to take off the seed coat as we plant the seeds?
> What is the juice of lychee and the coconut? Is there any stone in the coconut?
> What is the structure of durain? Where is the stone?
> What is organic planting?
> (Kon 5)
>
> After a discussion about the shape of the earth by comparing the length of the "radius" measured at various points, the pupils asked the following questions:
> Why do we measure only the northern hemisphere?
> Is the length of the radius in the southern hemisphere the same as that measured from the northern hemisphere? (Mon 2)

Although the student-teachers have reported that the pupils did not readily ask questions for fear of showing that they did not understand, a number of relevant questions were asked in the lessons observed. This indicates that the pupils had been thinking in the lessons and were aware of how the ideas may be applied. Nonetheless, these pupils may have received a lot of encouragement from the student-teachers for asking questions in class. This encouragement from the student-teachers is also a demonstration of the degree of confidence in science teaching, as they had indicated a fear of being unable to answer pupils' questions before they studied the Curriculum Studies module.

(iii) Asking pupils to predict results of practical activities

A third way of helping conceptual change is by asking pupils to predict the results of practical activities and then test out their ideas. Three of the lessons observed involved asking pupils to predict the results of practical activities as a way of stimulating pupils to think. Student-teacher B invited his pupils to predict whether the objects were transparent by filling in a worksheet:

> The teacher explained that he would invite some pupils to participate in the activity who would put the objects on the projector to see if light can pass through. The pupils were asked to complete a worksheet in their seats. They had to predict whether the object was transparent or not. (Bon1)

Having found that the pupils were able to predict the results of the practical activities, student-teacher B focused the subsequent discussion to help pupils build a new idea. For example:

> The pupils could predict if light can pass through the object. The emphasis of discussion becomes the concept of transparency, meaning that light can pass through the object. (Bon 1)

The prediction of results allowed the student-teacher to elicit the students' preconceptions. Their answers also informed the student-teacher of what to emphasize in the subsequent discussion.

(iv) Illustrating by using a range of examples

The fourth way of helping conceptual change is by illustrating the concept with a range of examples. Altogether ten of the student-teachers employed this strategy in helping pupils to change their concepts. Four out of ten of these student-teachers chose to widen the teaching content and included concepts that were extended beyond those taught in the textbook. For example:

> The student-teacher asked the pupils if all the flowers have the same structure and if all the parts are always present. He asked the pupils to give examples. The pupils suggested that daffodils do not have sepals and the same for the Christmas flower. The pupils were not sure how the structure of these flowers compared with the

> model flower. The student-teacher also suggested that the white Lily does not have sepals. The student-teacher asked the pupils to think about the structure of these flowers before the next lesson. (This part occurred at the end of the lesson after the different parts of the flower were discussed. The various examples of flowers mentioned are not covered in the textbook. The teaching includes a discussion of the structural modification of the flowers.) (Con 5)

> The student-teacher distributed worksheets on the cause of algal bloom. The worksheet included an article from the newspaper. The student-teacher encouraged the pupils to think about the problems on the worksheet. (This activity was conducted after the group discussion on the various causes of water pollution. The algal bloom was a piece of news featured in the local newspaper during that time.) (Don 6)

Other student-teachers (6 out of 10) made use of a wide range of examples to illustrate the teaching content. Pupils' understanding of the topic was enhanced by the opportunities to apply or test out their ideas through the examples. For example:

> The student-teacher provided various examples to apply the concept of poor and good conductors of heat. The examples used include: spoons with metal or plastic handles; frying pan; the rice cooker and the iron. (Mon 2)

> The student-teacher used two demonstrations to let pupils think about the concept of expansion and contraction. One demonstration involved the use of a metal ball and a metal ring. The other involved the use of a balloon fitted to a jar. The expansion of air inside the balloon was effected by dipping the jar in hot water. (Jon 5)

Based on the experience of the researcher as a teacher educator, in general, it is difficult for the student-teachers to include science contents that are not found in the textbook. However, the student-teachers observed in the study had attempted to include a wide range of examples in their science teaching. Although the content may not always be widened, this shows at least their willingness to include more examples to illustrate the science ideas. Moreover, a number of them had in fact widened the content to be covered. The student-teachers in this study were ready to adjust the teaching content according to the preconceptions of their pupils. This concept of helping pupils to build up their ideas was congruent with the constructivist view of learning.

(v) Illustrating by using practical activities

Another way of helping conceptual change is by illustrating ideas using practical activities including teacher demonstration of science investigations. Five of the student-teachers used demonstrations in their lessons. Two of the student-teachers attempted to facilitate new understandings among the pupils through demonstrations. For example:

> The formation of shadow was demonstrated using a number of objects and an overhead projector. (Bon 1)
>
> The production of sound was demonstrated using rods, chopsticks and coins. (Eon 1)

Two other student-teachers asked the pupils to learn about the concept, and the demonstrations were used to illustrate how the idea worked in actual situations.

> The student-teacher demonstrated two practical activities illustrating the concept of expansion and contraction. (Jon 2)
>
> The student-teacher showed the pictures and samples of seeds to the pupils as they were having a discussion about seed dispersal. (Lon 5)

One of the student-teachers used the demonstration to show how the idea was implemented in daily life situations. For example:

> A demonstration using household or kitchen utensils was used to show how the idea of poor and good conductors is applied. (Mon 2)

Demonstrations were more common among the lower primary and where the activities involved the use of heat or hot objects. Despite the constraints of the physical settings of the classroom, the student-teachers were ready to conduct demonstrations to illustrate what they were talking about. After taking the module, they appeared to be more confident with the demonstrations that involved heat or hot objects and were aware of the safety concerns. Despite the fact that conducting demonstrations in the classes involved more preparation from the teachers, the student-teachers were willing to do so.

(vi) Relating new ideas with previous concepts

The student-teachers were aware of how the concepts were related with each other in the topic and thus one of the ways to help conceptual change was to make linkages between new and old ideas. Five student-teachers established linkages between the newly learnt ideas with previous concepts. Making linkages between topics during teaching is uncommon when teachers in Hong Kong teach according to the textbook, and each topic is treated as a separate unit. The linkages came in different forms. Four of the student-teachers linked the content with another sub-topic under the same theme, for example:

> T: How do plants disperse pollen?
> P: By insect and by wind.
> T: The seeds are dispersed in various ways. I want to see how much you know about this. (The dispersal of pollen is compared with the dispersal of seeds.) (Lo 5)

> The student-teacher invited two pupils to try the hotness of the spoons. The pupils reported their feeling about the hotness. The student-teacher asked the pupils to explain the results. The student-teacher tried to remind the pupils to explain with reference to the game in the previous lesson and that Mr. Heat was carried to the finish line first by the metal rod. (Mon 2)

One of the student-teachers tried to link the content with another topic in the General Studies:

> The student-teacher asked the pupils what was inside the ovary (of the flower). The pupils suggested that it was ovules and the student-teacher asked them to compare this with the female reproductive cells in humans. The pupils said that the parallel is the fertilised egg. The student-teacher asked them to think carefully if the egg or ovule is fertilised at this stage. The pupils concluded that as the pollen has not yet arrived, it was then the egg. They then compared the ovary of the flower with the ovary in humans. (Con 5)

The second form of linkage was less common among the student-teachers as this required the teacher to have a clear picture about how the concepts were organised in the General Studies curriculum. The teacher also needs to be conversant about when the pupils come to know about the relative concepts. However, establishing linkages between concepts in the same topic is helpful for the pupils to build up their understanding about the topic. This was also one of the emphases of the

Curriculum Studies module, as an example of how related concepts were organised in the topic "Air" was discussed.

(vii) Using the newly learnt ideas in new situations

Another way of helping conceptual change among pupils is by inviting the pupils to use the newly learnt ideas in new situations. This type of activity usually occurred near or at the end of the lesson when most of the activities were completed and the student-teacher wanted to challenge the pupils to see how well they had learnt. These involved cases for analysis or situation questions that allow pupils to apply their ideas in finding the solution. Seven of the lessons observed were seen to have included this part. For example:

> After a discussion about the formation of shadow, the position and size of the shadow with reference to the light source, the student-teacher showed a picture with a boy and asked the pupils to draw the position of the shadow when the sun was directly overhead. The pupils succeeded in drawing the position. The next question was to ask the pupils to draw the shadow as the sun is on the west. The pupils had some difficulty doing this and could explain the position verbally but were unable to represent it in drawing. (Bon 1)

> After a discussion of the structure of flowers, the student-teacher asked the pupils to find out the differences in structure between different types of flowers and note their specific differences. (Con 5)

> The student-teacher presented a case on algal bloom for the pupils to analyse after a lesson on water pollution. (Don 6)

These quotations illustrate how the student-teachers included problem cases in their teaching and let pupils apply their new ideas developed. The use of these problem cases allowed them to check pupils' understanding and to extend their inquiry in the topic.

(viii) Pupil initiated activity

Pupils initiating activity can also help to effect a conceptual change. In the lessons observed, the pupils seldom initiated an activity by themselves, but were usually encouraged or invited by the student-teacher. In 2 of the 11 lessons observed, pupils initiated activities as follows:

> The student-teacher asked the pupils to suggest different ways of producing sound by the can. The pupils suggested to use hands to beat the can. Another suggested to put water into the can and beat the can with a stick. Another suggested to shake the can after filling it with water. The student-teacher encouraged the pupils to suggest alternatives and not only using hands. The pupils liked to use water. (Eon 1)

> The student-teacher demonstrated the difference in the conductivity of heat through two spoons made of different materials. The pupils suggested to test using cold water and see which one was cooler. (Mon 2)

As suggested by the student-teachers after the lessons, these activities would be tested out in subsequent lessons. This was not common among the lessons conducted by student-teachers although there were two in the lessons observed. This shows that the pupils were really interested in the lessons and have a desire to know what will happen in other situations.

(ix) Clarifying pupils' ideas by using other examples

This strategy was most frequently used by the student-teachers to clarify pupils' newly learnt concepts and was employed by six of the student-teachers. For example:

> The student-teacher concluded that sound production is related to vibration (after a discussion on production of sound and vibration). The student-teacher asked the pupils to provide counter examples of things that produce a sound but do not vibrate. The pupils suggested using transparent paper, this was disproved by blowing on the paper. (Eon 1)

> The student-teacher provided the length of the "radius" of the earth measured at different points to guide pupils to find out that the earth is not a sphere. (Ion 4)

> The student-teacher suggested that the pupils compare the fruit structure of a variety of fruits to help them realise the difference and similarities between them. This later leads to a series of questions from the pupils about the structure of different types of fruit. (Kon 5)

In order to be able to suggest counter or other examples, the student-teachers had to have a good understanding of the content themselves. Having counter or more examples to think about, the pupils became clearer of the science concepts. The student-teachers had therefore also regarded the ability of the pupils to distinguish between similar ideas as one of the learning outcomes of their lessons.

6.2.3.2 An overview of the lessons conducted by the student-teachers

The transcriptions and the field notes of each of the observations were analysed and teacher actions that agreed with those in the checklist were counted and are summarized in Table 6d. The counts were made if a particular action was found in the observation, and then taken as an occurrence or match. Thus, the nature of the actions are described and the count represents the frequency of the actions among the lessons observed, these are reported in the coming sections.

Eight out of eleven of the student-teachers attempted more than half of the nine actions in the checklist in the lesson observed (Table 6d). With the exception of two observations, the student-teachers attempted teaching based on a constructivist view of learning in all the lessons observed. From a total of nine actions in the list, student-teacher B has attempted all of these in his lesson, while student-teachers C, E, L and M had eight or seven matches on the list. This can be viewed as the influence of the Curriculum Studies module on their view of science learning, which was translated into the teaching actions in the classroom.

Table 6d Summary of matches with the checklist of teacher actions for each case

Student-teacher	**Topic taught in observed lessons**	**Primary Level**	**Age of pupils in years**	**Number of matches in the checklist**
B	Heat	1	6	9
C	Reproduction	5	11	8
D	Water Pollution	6	12	5
E	Sound	1	6	8
G	Reproduction	5	11	3
H	Noise Pollution	6	12	5
I	Earth	4	10	6
J	Heat	2	7	3
K	Reproduction	5	11	7
L	Reproduction	5	11	6
M	Heat	2	7	9

When each of the teaching actions on the checklist was considered for the whole group of student-teachers (Table 6e), the student-teachers attempted presenting questions for pupils, illustration by a range of examples, and presenting a case for pupils to think about, with relatively higher frequencies.

Table 6e Summary of occurrences of teacher actions

Teacher actions that are consistent with teaching science based on a constructivist view of learning	**Occurrences in all the lessons observed**
Presenting questions for pupils	11
Inviting pupils to ask questions	3
Asking pupils to predict results of practical activities	3
Illustrating by using a range of examples	10
Illustrating by using practical activities	5
Relating newly learnt with previous concepts	5
Using the newly learnt ideas in new situations	7
Pupil initiated activity	2
Clarifying pupils' ideas by using other examples	6

Based on the experience of the researcher as a teacher educator, teacher actions such as: relating new concepts with previous ones, inviting pupils to ask questions, having pupil initiated activity, and teaching related topics that were not found in the textbook were very uncommon, if not non-existent, among student-teachers or teachers with an arts background. On the whole, the student-teachers in the study shared considerations that relate to teaching science based on a constructivist view of learning. It appears that the Curriculum Studies module had influenced the student-teachers not only in their views of teaching and learning but also their classroom practice.

6.2.4 Perceived influences of the constructivist view of learning on teaching

Having described the lessons taught as perceived by the student-teachers themselves (6.2.2), from the records of the lesson observation (6.2.3), this section describes the perception, of the student-teachers about teaching science with a constructivist view of learning. The following question was raised in the interviews:

> How do you feel about having to teach science topics with a constructivist view of learning?

After the experience in the teaching practice, the eleven student-teachers interviewed had different positions about the influence of the constructivist view of learning in their own teaching (Table 6f). Six out of the eleven who had taught science topics in the teaching practice suggested that they have taken into consideration pupils' preconceptions as they taught. Two thought that their teaching was less bounded by the textbook. Three others described it as a workable way of teaching and these student-teachers did make a number of efforts to engage pupils in thinking in the lessons observed. In summary, there were positive, neutral and negative views. Positive aspects of what the constructivist view of learning means for teaching were more frequently mentioned. These include relating the constructivist view of learning to teaching as taking into consideration pupils' preconceptions, making one's teaching more pupil-centered, giving more consideration for the arrangement of topics, and the ways to represent abstract ideas. For example:

> I arrange the concepts in a logical sequence...It is helpful to arrange the topics in a logical sequence. By being more aware of the pupils' changing concepts, I can better organise the teaching scheme. (Ei3)

> In my previous teaching practice, I followed the text more closely and did not consider pupils' preconceptions. This year I am more aware of what pupils already know and may skip the basics. I choose the more detailed concepts and I do not follow the sequence in the book. I consider what pupils know about human (reproduction, the previous topic) when I teach about (the reproduction of) plants. I relate their concepts and plan the whole topic. I have more considerations as I plan. I consider how to represent abstract ideas by using more concrete examples such that the pupils may find it easier to understand. (Ci3)

> I try to think from the point of view of the pupils. From their perspective, I correct what they think and add on to what they already knew. My teaching is at least more pupil-centered. (Gi3)

These student-teachers had given more thought to the topic sequence, pupils' preconceptions, and building up pupils' concepts. These considerations are uncommon in "typical" science lessons in Hong Kong.

Table 6f The relationship between the constructivist view of learning with teaching as perceived by the student-teachers
(N=11)

How the student-teachers think the constructivist view of learning may influence their own teaching	Occurrences in the interviews
Positive comments	
Take into consideration pupils' preconceptions	6
Workable way of teaching	3
May not follow the textbook	2
Consider how to represent abstract ideas by concrete examples	1
Arrange topics in a logical sequence	1
Teaching becomes more pupil-centred	1
Ask pupils to conclude their answers	1
Neutral Comments	
Would consider different teaching approaches	1
Consider the nature of the topic	1
Would work if know the pupils better	1
Concerns	
A difficult concept	1
Not enough time to find out pupils' preconceptions	2
Hard to require the whole class to think, some are reluctant	1

Neutral views like considering a number of teaching approaches and depending on the nature of the topic were also mentioned. Others pointed out the limitations in the classroom context such as insufficient time available for teaching and finding out pupils' preconceptions, and the reluctance among the pupils to think and their difficulty in understanding the concepts. The reluctance among the pupils to think and the limited time available were described:

> (Do you think your pupils really think in class?) Some of them do, some do not. If you can arouse their interest, they are better. It is hard to require the whole class of pupils to participate. It is hard to require the whole class to think; some may not be interested. (Mi3)

> I would ask them how much they know before I teach and decide

> what to teach afterwards. I hope that I can do this. However, there is limited time and even if I have the information, there is not enough time to cover it. The pupils may not cooperate. It is important to know their preconceptions and teach accordingly, however, in reality, I don't have the time to find out these preconceptions. (Di3)

From the proportion of positive comments, it appears that the Curriculum Studies module influenced the student-teachers to have more consideration of pupils' preconceptions, to design their own topic sequence and not to be bounded by the textbook. Moreover, there were considerations about other teaching strategies that they knew of and the contextual situations, such as the nature of the topic and the knowledge about the pupils.

6.2.5 Summary

During the teaching practice period, the student-teachers' descriptions about how the lessons were prepared reflected a number of contextual concerns (like time, classroom management, safety and pupils' ability) as they attempted to put what they have learnt about science teaching into the classroom context. These were new concerns that were not mentioned in previous interviews. Moreover, nearly all of them related consulting colleagues or peers as an important part in planning. These suggest the importance of the contextual influence on their teaching and how they valued professional discussions. The teaching strategies that were employed by the student-teachers correlated closely with those advocated in the Curriculum Studies module about getting pupils to think, helping pupils to link up concepts and apply newly learnt ones. Teaching was found not to be tightly bounded by the textbook, nor trying to catch up with teaching schedules, but was seen as adjusting the content and topic sequence in view of pupils'. preconceptions. Pupils were encouraged to ask questions and to participate in activities. These are opportunities that facilitated interactions between the teacher and the pupils as well as interactions between the pupils to occur. A large proportion of the student-teachers (six out of eleven) identified their teaching with a constructivist view of learning and they observed noticeable differences in their science teaching when compared with the teaching practice of the previous year. This may be interpreted as the influence of the Curriculum Studies module as an intervention in the present study.

6.3 Science learning in the lessons observed

This section describes the science learning of the pupils in the lessons observed. The first part is an analysis of the learning conditions and the second portrays the learning outcomes as perceived by the student-teachers. The findings reported were obtained from the field notes, lesson observation records and the interviews with the eleven student-teachers during and after the teaching practice period.

6.3.1 The learning conditions

In the present study, it is important that the student-teachers found that teaching science based on a constructivist view of learning could actually result in better learning among the pupils. The learning conditions in the science lessons include the motivation to learn, enjoyment of the pupils, and social support in learning through pupil-pupil interactions. The teacher-pupil interactions were described in the previous section 6.2.3.3 as the lessons observed were analysed.

In order that learning can occur, three of the student-teachers found that there must be a change in the attitude or the learning style of their pupils. For example:

> The activity may be dominated by one or two pupils. Another problem is that they like to find out answers from the textbook. There may be things that they don't know but they don't want to tell you. (Ci3) (see Chapter 3, Section 3.4.2 for details on the coding)

> These are very simple but they are not too serious about it. If they try to think, they can find out some ways of reusing a bottle. (Di3)

> If you can arouse their interest, they would be better. It is hard to require the whole class to participate. It is hard to require the whole class to think, some may not be interested. (Mi3)

Among all the lessons observed, the researcher noticed that the pupils were in fact interested during the group activities, the demonstrations or the group discussions. Among eight of the lessons, there were signs that the pupils were enjoying the lesson. These included volunteering to participate in the demonstrations and to answer questions. Two of the observed lessons were found to be particularly enjoyable for the pupils:

> The teacher warned the pupils not to eat the fruit during the activity.... Some pupils played with the orange and squeezed the juice from it. The pupils said that they were trying to find the seeds. Some pupils have finished or wrote their findings on the blackboard. The pupils had a good time trying to smell, cut up and even taste the fruit. (Kon 5)

> The teacher asked the pupils to divide into groups of 4 to 5 and draw the various kinds of landscapes they think is present on earth. ... The pupils drew buildings, trees, ferries, cars, swings, waterfall, farmland and other geographical features including: oceans, low land, plateaux, deserts, volcanoes, hills and rivers. Some were drawn with colours on the picture. The teacher collected the pictures and commented that they were good. (Ion 4)

In three of the lessons, the pupils were restless and the student-teacher could not maintain their attention when he/she was conducting the discussion with the whole class. Even so, in one of these three lessons, the teacher was still able to obtain responses from pupils and the whole class discussion was meaningful. In the other eight lessons observed, the pupils were able to offer constructive answers to the questions raised by the student-teachers. The pupils were asked to report their observations during the demonstrations or the group activities, to explain what they had observed, to apply the ideas they have learnt, to represent their ideas in drawings, and to predict the results of the practical activities or the demonstrations.

In nine of the lessons observed, the student-teachers used group discussions to get students thinking. Eight out of the eleven student-teachers included this as a means of making pupils reflect on the content. The other three student-teachers were observed in lessons when they had classroom management problems and did not implement group discussions. It was apparent to the researcher that the pupils enjoyed the discussion and were mostly able to arrive at meaningful conclusions after the discussions. Four of the group discussions were framed by worksheets, with the student-teacher providing worksheets before the lessons to guide the pupils. These kept the pupils on task as well as provided a guideline for reflection. The student-teachers reflected on the effectiveness of the discussions. For example:

> My pupils do not like to tell what they think in class. It is very boring if I do all the talking in the lesson. Some of the pupils talk among themselves (about other things not related to the lesson). I set the questions in the worksheet and I want each of them to participate. (Di3)

> I guide them to find out the conclusion through the discussions. I would not tell them the answers directly. I want them to think about it based on what was learnt in the previous lessons, and think about what should be added on to in the present lesson. (suggesting a development of pupils' concept) I do not use a direct way of telling them but use an indirect way. They have to think before I tell them. (How far have you achieved your aim?) I think I have achieved what I planned. (How about making them think?) I believed that they have discussed though some may refer to the textbook afterwards. (Hi3)

> I use discussion cards and provide also matching options for them. If you just asked them to discuss, they cannot make it. They need more guidelines and hints. They can then choose and complete. I also give them pictures. They have low ability. I have to force them to think and they are not so used to it. (Li3)

Other student-teachers used pictures, practical activities or activities such that discussion became part of the group activities. A student-teacher reflected on how the activities have helped pupils to think.

> I would give them some pictures as a stimulation for thinking. The visual stimulus can make the message less abstract in comparison. There are also chances for them to have hands on experience. Through these, there will be more questions for them to think about. After the experience, they have more basic understanding, then more questions about the topic can be raised. (Ki3)

The student-teachers made good use of the discussion cards, worksheets or pictures to guide their pupils to reflect, think about the topic and keep them on task. They were also able to follow on pupils' ideas as a lead into further investigations into the topic. The use of group discussions and the interactions between the pupils were valued by the student-teachers who have tried various strategies to keep the discussions meaningful and focused. In this way, the sociocultural environment had been managed by the student-teachers to maximize the opportunities for construction of new ideas to occur.

6.3.2 The learning outcomes

While the student-teachers were able to identify the learning conditions that helped their pupils to learn, they also related a number of learning outcomes that indicated better learning in their pupils. The learning outcomes that the student-teachers expected from their pupils include: being attentive in making observations and being able to explain them by applying what was learnt. Four student-teachers described how they expected the science learnings to have an impact on the pupils:

> They are interested to know and learn about how the earth moves and other things like the satellites. This can be applied as they talked to their classmates and their parents. For example, they are able to understand why volcanoes and eclipses occur as they watch the news. They can explain the phenomena with what they have learnt from the lessons. They will talk about this in their daily conversations. (Ii3)

> The pupils will apply these (the concept of heat and transfer of heat) in their daily life experiences. There are kettles at home, they have to hold their cups. I can ask them to observe things around them e.g. see the gaps in between the concrete blocks and observe the rail of the trains. (Ji3)

> I can tell the pupils to be more observant at home. It would be interesting to ask them to study the orange or flower whenever they have one in their hand. (Ki3)

> I have used questions and what they have learnt in the previous three lessons as a basis. From then the activities help them to apply them in explaining objects that they will find in their daily life experiences. (Mi3)

One of the student-teachers also used the quality of questions raised by their pupils as an indication of their learning:

> I give them some questions, they think about it and tell me what they have figured out. The pupils may then raise some questions and ask me. ...They ask funny questions. It depends on their motivation, if they are just making tricks on me, I throw the question back to them. If the question is meaningful, I share it with the whole class. I encourage them to ask more questions. (Ki3)

Three of the student-teachers also regarded the ability of their pupils to apply the new concepts in new situations and being able to distinguish between ideas as an evidence of learning. The student-teachers described how they provided opportunities for pupils to apply what they have learnt:

> I asked them where the shadow is if the sun is directly above, and the difference if the sun is on the west. They can tell that the shadow is on the ground and next to the person. However, they cannot express the fact that the shadow was elongated. It seems to be too difficult for them if I make this too detailed. (Bi3)
>
> In the topic of magnetism, there is a sub-topic on the application of magnetism. I have done a demonstration on the attractive force of the magnet. In one of the activities, I pretended that I had dropped all the paper clips on the floor and asked the pupils how I could pick them up. Some of the pupils were able to apply the idea of attraction and use a magnet to attract them. (Bi3)
>
> I bought some magnets for the pupils and asked them to design some toys with them. The pupils do make use of the principles of attraction and repulsion to make some games e.g. fishing and attraction through a piece of paper. (Ei3)

To be able to distinguish the similarities and differences between science concepts was also seen as a way of reflecting pupils' learning by two of the student-teachers:

> I would try to find some examples that are not attracted by magnets. They can discover that not all metals are attracted. They discover their own mistakes. ...Pupils do think that all the transparent things are colourless. I then bring in transparencies that are coloured. The pupils can now distinguish between colourless and transparent. (Ei3)
>
> I provide some examples and asked them to distinguish what is oviparous or viviparous; external or internal fertilisation. They can revise on the topics and then classify the animals by the ways of reproduction. (Ci3)

The learning conditions include a number of changes among their pupils, namely their attitude towards learning, developing an interest in science, and being able to share their ideas with others. Moreover, the ability to apply science concepts in new situations, to ask questions, and to be able to distinguish similarities and differences between science concepts were counted as positive learning outcomes of the lessons. The student-teachers had therefore seen better learning among their pupils as they teach science based on a constructivist view of learning. It may be interpreted as an important condition for the student-teachers to continue their endeavor to teach science based on a constructivist view of learning.

6.4 Perceived problems and influences during the teaching practice period

The previous section in this chapter has described what the teaching was like in the teaching practice period. In this section, the student-teachers' perceptions of the problems and the influences that may affect their science teaching are described.

6.4.1 Perceived problems in teaching science

The findings described in this section were obtained from a questionnaire survey (Appendix C4) among the 20 (out of the whole group of 39) student-teachers who taught science topics during the teaching practice period. They were invited to rate the degree of difficulty that they experienced in relation to six tasks:

- understanding pupils' preconceptions
- having sufficient science academic knowledge
- conducting activities
- conducting practical activities
- classroom management
- stimulating pupils to think.

In the interviews before and after the student-teachers studied the Curriculum Studies module, they mentioned that they were concerned about these tasks (except classroom management) in their lesson preparation. The item classroom management was added as the researcher perceived that this may have a significant impact upon the student-teachers' teaching as observed in some of the lessons. The ratings were made from a 0, 1 to 5 scale with 0 meaning no difficulty, 1 indicating little difficulty and 5 indicating extreme difficulty.

The student-teachers did not think that they experienced too much difficulty with teaching science, as the mean rating for the items for perceived level of difficulty were low to medium, ranging from 2.25 to 2.60 on a 5-point Likert scale (Table 6g). Comparatively, their perceptions of difficulty in teaching science were more associated with conducting practical activities, stimulating pupils to think, conducting activities (e.g. discussions, games), and classroom management, than with having sufficient knowledge and understanding pupils' misconceptions. The difficulty of conducting practical activities is comparable with that for stimulating pupils to think, although the former was perceived to be at a higher level of difficulty (Figure 6a). Given the physical limitations of the primary classrooms, it was not surprising to find that the student-teachers perceived conducting practical activities as a difficult task. Above that, these student-teachers did not have a science background in their secondary education and this may lead to more concern about conducting science practical activities than with other activities. Classroom management was not perceived to be a serious difficulty for the student-teachers. This may be due to the fact that these student-teachers were already in their second teaching practice and that their concern had shifted from emphasis on classroom discipline to attracting pupils' attention to learning. Understanding pupils' preconceptions was perceived to be relatively easy for the student-teachers as the module included a number of ways to identify pupils' preconceptions, and one of the assignments was to investigate pupils' preconceptions on a certain topic. However, stimulating pupils to think seems to be a more difficult task as the pupils in primary schools are more used to memorisation, and listening to the teacher. Together with the tight teaching schedule, in general, few primary teachers in Hong Kong would normally attempt to do much to stimulate pupils to think. Although the student-teachers attempted a number of ways to engage pupils in thinking in the lessons (as reported in sections, 6.2.1, 6.2.2 and 6.2.3), the results in this part showed that the student-teachers did experience a certain degree of difficulty in these attempts.

Table 6g Perceptions of the level of difficulty of conducting various tasks in the teaching of science (among student-teachers who have taught science topics in their teaching practice).
(N=20)

Task	Mean
Understanding pupils' preconceptions	2.25 (1.48)*
Conducting practical activities	2.40 (1.10)
Classroom management	2.45 (1.28)
Having sufficient science academic knowledge	2.50 (1.49)
Stimulating pupils to think	2.55 (1.23)
Conducting practical activities	2.60 (1.14)

* Values in brackets are S.D.

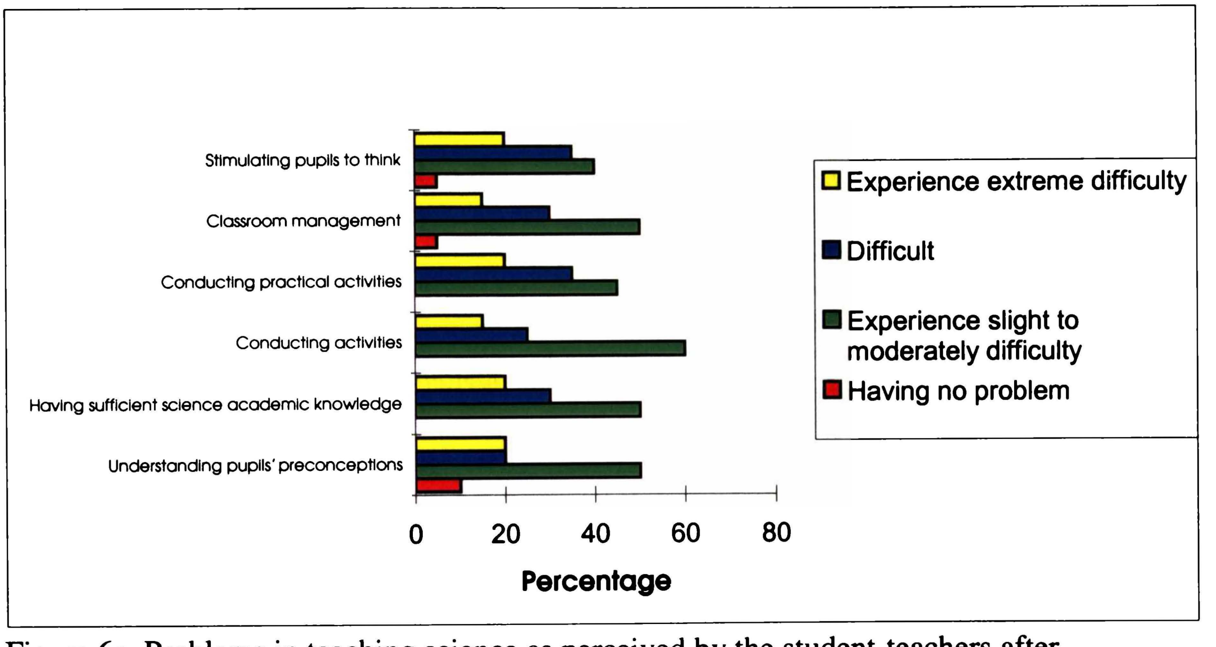

Figure 6a Problems in teaching science as perceived by the student-teachers after the teaching practice
(N=20)

6.4.2 Influences on teaching the planned lessons

The views about planning science lessons changed after studying the module, as discussed in section 5.4.1, and the student-teachers intended to include a number of considerations based on the constructivist view of learning in their planning before the teaching practice period (section 6.2.1). However, whether these intentions can be put into practice depends on a number of factors (Table 6h). In the interviews with the eleven student-teachers, they were asked to describe perceived influences on their science teaching during the teaching practice. Their responses can be grouped into two main categories. There are factors associated with the teaching context, such as the classroom discipline (6) and the ability (3) and attitudes of the pupils in learning (3). One of the student-teachers had serious problem with classroom discipline:

> I think the discipline problem is more influential. My activities are all feasible and can attain the learning objective. However, the pupils are too restless and it is too noisy. It influences the effectiveness. I do not even know what I am doing. Pupils run around and do not participate. (Bi3)

Table 6h Influences on the effectiveness of the planned science lessons as perceived by the student-teachers
(N=11)

Influences as perceived by the student-teachers in achieving their intentions to teach science based on a constructivist view of learning	**Occurrences in the interviews**
Influences related to the classroom or school context	
Discipline problems	6
Attitude of pupils in learning	3
The ability of the pupils	3
Physical settings of the classroom	2
Resources available	2
Teaching method of the original subject teacher	2
What pupils already know	1
The requirements of the school	1
Time available	3
Influences related to the content of teaching	
The relevance of the topic to daily life experiences	1
Whether the practical activity is successful or is interesting to the pupils	2
Pupils asking out of scope questions	1
Teacher competence	1

The second most frequently mentioned influence (by three student-teachers) was the attitude of the pupils to learning, and their ability. For example:

> Sometimes they are very attentive but sometimes they don't care what you are doing. It has a very great impact on me. You know very quickly in the first five minutes. I have an experience that they could not sit down in the first ten minutes. (Di3)

Three student-teachers have also reported how they adjust their teaching according to the ability of the pupils. For example:

> Sometimes there will be a discrepancy between what the pupils

> really know and what I expect. If they know more than I expect, I can teach in more detail. (Ki3)
>
> The response of the pupils, for example, if they all know that the earth is slightly flattened, then there is not much to be taught on this part. This will also influence what should be taught later. (Ji3)

Another described how she attempted to change the attitude of her pupils:

> I have asked them to complete a worksheet and think about what is their attitude towards rubbish treatment. These are very simple but they are not too serious about it. If they have thought, they can find out some ways of reusing a bottle. Their ability is low and they are reluctant to think. I force them and help them. They did not hand in their work as they don't know how to do it. I forced them to hand in and answer questions in class. I also give them a lot of opportunities to think in class by asking them questions. I make them participate and not play in class. (Di3)

The above factors were mainly concerned with the pupils' ability and attitude, which make up the classroom context. Another group of factors in the same category was related to a wider school context that includes: whether pupils could adapt to the teaching style of the student-teacher within the short period of time in the teaching practice, the constraints imposed by the school, such as requirements for homework and the teaching schedule. Two student-teachers also found the teaching style of the original class teacher had an influence over their teaching. The pupils expected them to teach in much the same way while they were trying to teach in a different way. For example:

> Their previous habit in learning also affects the situation. They rely much on me to tell them how to do the workbook. (Li3)
>
> The teaching method of the original class teacher also had an influence on my teaching. It takes time for the pupils to adapt to my teaching and in grouping the pupils, how to move the chairs and sit in groups. I have to consider how she taught before. (Hi3)

Two student-teachers described how the physical settings of the classroom, and the time and resources available influenced their teaching.

> Due to the environment in the classroom, the practical activity did not work in the air conditioned room. The matches did not light and I had to heat the rods with a lighter. The butter on the glass rod did not melt, only those on the metal rod melted (meaning that the butter on the glass rod should melt eventually though much slower than that on the metal rod). The environment is a limitation

> even if you have good preparation. (Mi3)
>
> The size of the classroom limited the area of my movement. I could not really walk around the class to help them during the activity. The school announcements interrupted my teaching. Sometimes I could not find the resources or the models for illustration. (Ci3)
>
> Resources, for example, I hoped to show the pupils more pictures but I could not find them. I didn't have samples of different types of rocks and I could not show the pupils. This made the lesson less interesting. (Ii3)

Three of the student-teachers described how they were anxious to keep up with the teaching schedule and that they could complete the topics within the given time period. For example:

> Time is limited and the content cannot be left for the next lesson. (Li3)
>
> Sometimes pupils may ask questions out of the scope. This affects the timing of the lesson. This class of pupils has a lot of questions to ask. Generally, the pupils in this school are like this. It is good to ask questions but I would prefer to finish what I have to cover first. (Ji3)

The second category of factors is more concerned with the teacher's competence in relating the content with daily life experiences, in answering pupils' questions, and in conducting practical activities successfully. Two student-teachers raised the concern about designing practical activities and getting pupils interested during the practical activities:

> I have to be very careful about performing practical activities as well so that there will not be "unexpected" results. There are times that the design turned out to be problematic during the lesson. These may create wrong concepts among the pupils. I have to be careful about the design. (Ei3)
>
> If I am not familiar with the plan and the content, it affects the fluency of the teaching....Sometimes the practical activities are not attractive for the pupils. They may find it too easy and they know the results already. This is out of my expectation. (Ki3)

One mentioned the dilemma between letting pupils ask questions and the worry that he did not have sufficient information to answer the questions:

> Sometimes the pupils may ask questions out of the textbook. This affects the timing of the lesson. This class of pupils has a lot of questions to ask. Generally, the pupils in this school are like this.

> (Do you like them asking questions?) It is good to ask questions but I would prefer if I could finish what I have planned to teach first. I am also afraid that I cannot answer their questions, as my preparation may be inadequate. If I have all the information, then there is no problem. The teacher (I) may not be too familiar with the content. (Gi3)

The concern for academic content remained and this can be interpreted as related to the arts background of the student-teachers. A number of influences were identified by the student-teachers. Soicocultural factors that shape the culture of teaching and learning in school may impose a number of limitations that teachers have to face or solved though the degree of difficulty may vary within different school contexts. These include: classroom management, the physical setting of the classroom, and the time and resources available. Comparing the two groups of factors, concerns with the context were more frequently mentioned than concerns with the content of teaching. This can be understood, as the student-teachers may solve the problem related to content by reading up references, while the influences from the school context may be largely out of their control. As the student-teachers came to practice what they learnt, the classroom context, the school culture and the learning of the pupils became their major concerns.

6.4.3 Summary

From the findings in the quantitative and qualitative part of the study, the student-teachers did not experience serious difficulties in science teaching based on a constructivist view of learning. The low ratings in the questions of the questionnaire are consistent with the low frequency of student-teachers who mentioned the difficulties in the interviews. Despite this, the findings in the interviews suggest four major areas where the student-teachers experienced a certain degree of difficulty in their science teaching. The first area was classroom management, which was found to be a concern for six of the eleven student-teachers. This made conducting practical activities and group activities more difficult in the primary classrooms. The second area was about getting pupils to think. The attitude of the pupils to learning, their established learning habits with the original class teacher, and the ability of the pupils, were all found to be influencing the pupils' engagement in thinking during the science lessons. These two areas may be taken as sociocultural factors related to the classroom context:

pupils, learning habits, and other teachers' teaching style. These factors may influence the science teaching of the student-teachers. Thirdly, the student-teachers were concerned about their academic background knowledge in science. They shared concerns about answering pupils' questions, relating the topic to daily life experiences and having sufficient knowledge to conduct successful practical activities. This factor is associated with the previous learning experiences and the background of the student-teachers.

6.5 Feelings about teaching science in school

The development of confidence in teaching science can be taken as the personal development of the student-teachers. Moreover, an increased confidence may also mean that the student-teachers are more ready to implement the strategies introduced in the Curriculum Studies module. While the student-teachers' confidence may be understood through the interviews, their belief in their ability to facilitate pupils' learning through their teaching can be represented by measures of Science Teaching Efficacy Beliefs. The notion of Science Teaching Efficacy Beliefs is related to the sociocultural view of learning as it represents the purpose and motivation of teaching (Section 2.4.3).

6.5.1 The Science Teaching Efficacy Beliefs of the student-teachers

After the teaching practice, the Science Teaching Efficacy Beliefs questionnaires were mailed to the 39 student-teachers and a reminder was sent to the non-returns after one week. A total of 27 questionnaires was collected and among them 20 had taught science in their teaching practice. The response rate was around 75%, which is above the norm for mail questionnaires. Table 6i is a summary of the number of respondents in the quantitative part at the various phases of the study.

The Science Teaching Efficacy Beliefs (STEB) instrument (Appendix C2) measures the Personal Science Teaching Efficacy Beliefs value and the Science Teaching Outcome Expectancy value. The alpha reliability values of the Science Teaching Efficacy Beliefs instrument was found to have a value of 0.59 and 0.78

before the commencement of the module and after the teaching practice respectively. Higher values in each or both of them indicates that the respondent is more confident in science teaching. From the Personal Science Teaching Efficacy Beliefs and the Science Teaching Outcome Expectancy values, the student-teachers were more confident in teaching science after the teaching practice. The student-teachers had significantly higher personal science teaching self-efficacy and outcome expectancy after the teaching practice (Table 6j).

Table 6i Number of respondents for the measurement of Science Teaching Efficacy Beliefs (Appendix C2) before studying the Curriculum Studies module and after the teaching practice

Phase	**Number**
Before studying the Curriculum Studies module	39
After the teaching practice	27
Student-teachers who taught science during the teaching practice	20

Table 6j A comparison of the Science Teaching Efficacy Beliefs value in the present study and those obtained in previous studies

	Before taking the module N= 39	**After the teaching practice N=20**	**De Laat and Watters (1995) Australia**	**Riggs and Enochs (1990) USA**
Personal Science Teaching Efficacy Beliefs	38.77 (5.18)	42.23 (7.06) **	49.6 (range 33-62) S.D. 5.9	56.54
Science Teaching Outcome Expectancy	34.26 (4.02)	39.19 (8.47) **	33.9 (range 20-44) S.D. 5.6	48.09

** p<0.01 Values in brackets are S.D.

This means that the student-teachers believed more strongly in their own competence to teaching science and in effectively positive learning outcomes in their pupils after the teaching practice. Compared with the mean values from other studies of primary student-teachers in Australia (de Laat and Watters, 1995) and the USA (Riggs and Enochs, 1990), the mean values for Personal Science Teaching Efficacy Beliefs is still lower, but that for Science Teaching Outcome Expectancy is higher than the Australian study. Although the values were still lower, the increase was significant and comparable with that of the Australian study. Moreover, as reflected by the student-teachers, the confidence was comparable to that of teaching other topics in the General Studies curriculum and for some (65%) it was also comparable to teaching Chinese, the subject that takes up the largest amount of time in the teacher education programme (Table 6k).

Table 6k Perception of the student-teachers who have taught science topics in their teaching practice, (N=20) in their confidence to teach science after the teaching practice
(Appendix C4)

<table>
<tr><td></td><td colspan="2">Has increased after the teaching practice (percentage)</td><td>Has not increased after the teaching practice (percentage)</td></tr>
<tr><td>Confidence to teach science</td><td colspan="2">96.3</td><td>3.7</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Confidence to teach science</td><td>Higher</td><td>Same</td><td>Lower</td></tr>
<tr><td>Compared with confidence to teach other topics in the General Studies syllabus</td><td>20.0</td><td>70.0</td><td>10.0</td></tr>
<tr><td>Compared with teaching Chinese</td><td>20.0</td><td>45.0</td><td>35.0</td></tr>
<tr><td>Compared with teaching Maths</td><td>40.0</td><td>35.0</td><td>25.0</td></tr>
</table>

A paired sample t-test was conducted to compare the response in the Science Teaching Efficacy Beliefs instrument. Out of the 25 items in the Science Teaching Efficacy Beliefs instrument, 8 items showed a significant difference among the respondents before studying the module and after the teaching practice (Table 6l). These items showed that the respondents had more confidence with teaching science, knowing more about how to engage pupils in activities, knowing that their effort would take effect, and having comparable confidence in teaching science as in other topics. Their lack of knowledge about science concepts also contributes to the low confidence level before taking the module, as reflected by the mean values of items 8 and 12. However, after the teaching practice, this worry about content was lowered. The student-teachers had a more positive belief that their teaching was responsible for pupils' achievement and found themselves being able to help pupils experiencing difficulties after the teaching practice. As reflected by the increase in mean value for item 21 in Table 6l, they had confidence that their science teaching was good enough to be evaluated by the principal.

Considering the changes in the Personal Science Teaching Efficacy Beliefs and the Science Teaching Outcome Expectancy values on a case by case basis shows that more than half (54%) of the student-teachers experienced a gain in the sum of personal science teaching efficacy beliefs, while 85% showed an increase in the sum of outcome expectancy beliefs after the teaching practice. This means that the student-teachers held more strongly to their belief that their teaching can effect positive learning outcomes in their pupils than before. Comparatively speaking, this belief in effecting learning outcome was stronger than their belief in their own competence of science teaching. In other words, they shared the view that the pupils could learn better but that they were not as confident comparatively in their own teaching. Learning among the pupils was thus seen as being influenced by other factors besides their teaching.

Table 61 Items in the STEB instrument that shows a significant difference before studying the module and after the teaching practice

Items in the STEB	Mean before taking the module (N=39)	S.D.	Mean after the teaching practice (N=20)	S.D.	F value
3. Even when I try very hard, I do not teach science-related topics as well as I do most topics. #	2.65	0.69	3.50	0.81	4.67***
5. I know the steps necessary to teach science-related concepts effectively.	2.85	0.16	3.31	0.68	2.48*
8. I generally teach science-related topics ineffectively. #	3.12	0.82	3.77	0.65	5.30***
12. I understand science concepts well enough to be effective in teaching science topics at the primary level. #	2.50	0.81	3.00	0.80	2.31*
14. The teacher is generally responsible for the achievement of students.	3.35	0.75	3.65	0.80	2.54*
21. Given choice, I would not invite the principal to evaluate my science teaching. #	2.84	1.07	3.36	0.91	2.59*
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better. #	3.04	0.98	3.48	0.77	2.29*
24. I do not know what to do to get students engaged with science. #	3.00	0.82	3.64	0.70	2.87***

* $p<0.05$ ** $p<0.01$ *** $p<0.005$

Comparing the Personal Science Teaching Efficacy Beliefs values obtained before the module and after the teaching practice (Figure 6b), the difference in the values among individual cases ranges from a gain of 17 to a decrease of 19 points. The

Negatively worded items have been recoded such that a higher mean value indicates higher science teaching efficacy beliefs.

difference in values for the Science Teaching Outcome Expectancy among individual student-teachers ranges from a gain of 14 to a decrease of 14 points (Figure 6c). The range for the difference in the Personal Science Teaching Efficacy Beliefs values is 4 points wider than that for Science Teaching Outcome Expectancy (comparing Figure 6b and 6c). Hence, though the trend for the whole group is an increase in confidence level, there were two individual student-teachers who had particularly negative changes in Personal Science Teaching Efficacy Beliefs values and one of them also had negative changes in the Science Teaching Outcome Expectancy value. As the questionnaire was anonymous, the researcher could not identify the individual who experienced such negative changes. The explanation was made based on a postulation that the student-teacher may have had much difficulty in teaching science during the teaching practice. On the whole, the student-teachers experienced a significant increase in their confidence to teach science, and the amount of change depends on individual situations, their perception of learning in the Curriculum Studies module, and their experience in the teaching practice.

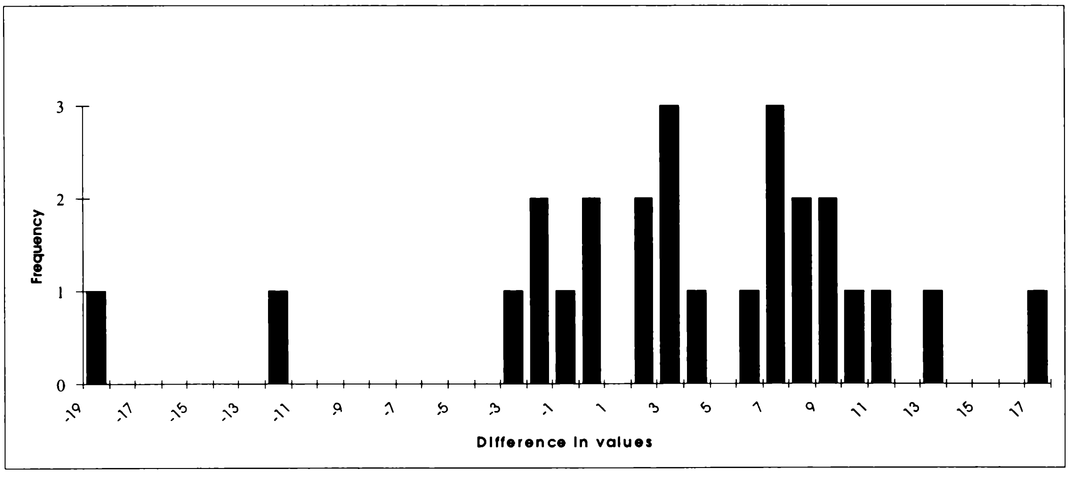

Figure 6b Difference in Personal Science Teaching Efficacy Beliefs values before and after the teaching practice

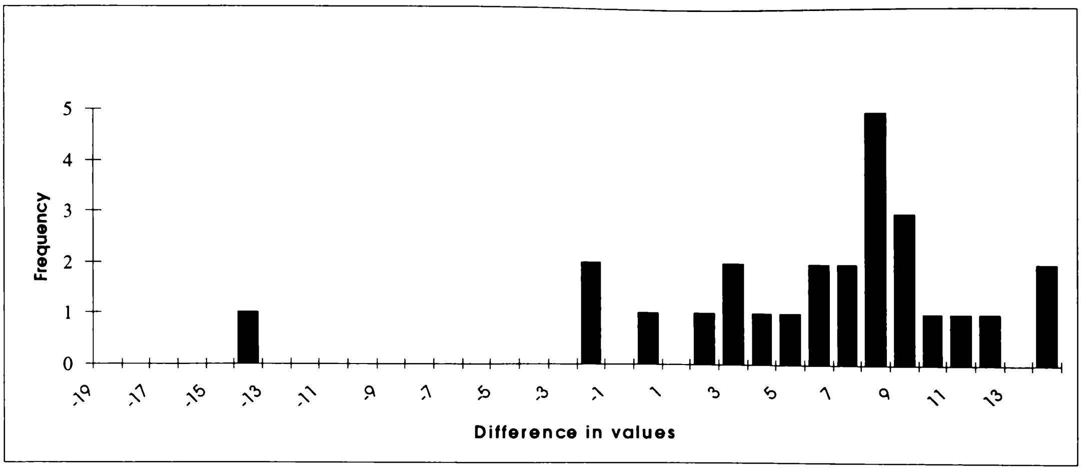

Figure 6c Difference in Science Teaching Outcome Expectancy values before and after the teaching practice

After the teaching practice, the responses from the student-teachers suggested an increase in confidence to teach science (96.3%) as shown in Table 6k. This corresponds to the significant increase in the Personal Science Teaching Efficacy Beliefs values after the teaching practice. A comparison of the confidence to teach science and other topics reveals whether the initial impression of having much worry about science teaching persists among the respondents. Over 90% of the respondents found themselves to have higher or similar confidence in teaching science topics as in other topics in the General Studies curriculum. As the subject Chinese takes up the largest amount of curriculum time in the teacher education programme, most of the student-teachers found this subject easier to manage and there were clear or well defined methods of teaching it. Around 65% of the respondents had higher or similar confidence in teaching science as in teaching Chinese. It is important that the student-teachers do not find science to be particularly difficult to teach as compared with other topics in the General Studies so that they will not try to avoid teaching it in future and this deprive their pupils of a chance to learn science.

The figures of the Personal Science Teaching Efficacy Beliefs, the Science Teaching Outcome Expectancy values and the percentages about the confidence levels to teach different subjects in the primary curriculum are consistent with each other. There was an overall increase in the level of confidence. The beliefs that one is more competent in teaching science and that one's teaching can effect positive learning outcomes was stronger. The student-teachers were more confident that their pupils experienced better learning, though they were comparatively less confident about their own teaching. Individual experiences in the teaching practice, and learning experiences may have some influence over the student-teachers' confidence to teach science. All in all, the majority of the student-teachers became equally confident in teaching science as other topics in the General Studies curriculum as well as Chinese. It appears that the Curriculum Studies module and the teaching practice had an influence on the student-teachers such that they become more confident in their science teaching.

6.5.2 Confidence to teach science in school

In the present study, the change in the confidence to teach science is taken as a form of personal development. The change may be interpreted as a result of the learning experience of the student-teachers in the second year of their teacher education programme. The feelings of confidence to teach are described in comparison with those from the interviews held before and after the Curriculum Studies module. These findings also support the quantitative results and provide explanations for the changes in the Personal Science Teaching Efficacy Beliefs and Science Teaching Outcome Expectancy values described in the previous section.

In order to find out the student-teachers' concerns, the question "How do you feel about being a science teacher?" was used in the interviews. Before the student-teachers took the module, the interview findings suggested that the student-teachers (13) shared a number of concerns about science teaching, and only two mentioned positive feelings (Section 4.5). Their concerns ranged from their content knowledge, answering pupils' questions, conducting practical activities, and helping pupils to understand the content. After taking the module, five reported that they found the subject interesting to teach, and three felt themselves to be different, as they knew more about science teaching (Table 6m). However, the concern over science content persisted and eight felt a lack of sufficient academic background. After the teaching practice, eleven out of the thirteen student-teachers (as they had a chance to teach science topics in the teaching practice period) were interviewed again. Their confidence in teaching science continued to grow as shown by the increased number of student-teachers mentioning this point (8), and more (4) felt that they had a sufficient academic background (Table 6n). One reported on a better control of the pace of teaching:

> I think teaching science topics is more interesting.... I have greater confidence this year. I have a better control of the pace of teaching this year. I can estimate the time needed for practical activities rather than just using discussions. (Bi3)

Table 6m Student-teachers' feelings towards being a science teacher after studying the module
(N=13)

Student-teachers' feelings towards being a science teacher	Occurrences in the interviews
Positive comments	
Feel different for having more knowledge in science teaching	3
Feel happy to be a science teacher and regard this as a recognition/ Confident to be a science teacher	5
Feel that they have sufficient science background for teaching at primary level	3
Have an interest in science	1
Negative comments	
Don't have much knowledge of science	8
Need more experience in teaching science	6

Table 6n Confidence to teach Science after the teaching practice
(N=11)

Perceived confidence to teach science	Occurrences in the interviews
Positive comments	
Found it more interesting to teach science	2
Had greater confidence	8
Had better control of pace of teaching	1
Able to tell if pupils are participating	1
Had sufficient knowledge in teaching the topic	. 4
Occupying pupils to think is effective	1
Being more aware of what pupils think	1
Pupils had better response	1
Negative comments	
Not much confidence	1
Depend on the time available for lesson preparation	2
Need to read more on the topics	2
Need more experience to find the way out	1
Influenced by discipline problem	1
Perceived a problem to conduct practical activities	1
Prefer to teach the upper primary	1

Another suggested that pupils had a better response in the lessons:

> I think that GS (General Studies) is easier to teach. There are practical activities in the topics and the pupils have a better response. It feels easier to teach. (Mi3)

Arranging practical activities increased the participation of pupils and this led to a better estimation of the pupils' learning:

> In the practical activities, I can easily tell who is participating. The learning outcome is more easily seen. I have greater confidence in teaching General Studies than other subjects. I can better prepare for GS (General Studies) lessons, there are activities and the pupils are more engaged. It is more interesting. (Bi3)

Occupying pupils to think led to feelings of success in teaching science (was mentioned by one of the student-teachers:

> I didn't have any confidence before I taught as the subject teacher had told me that they had low ability.... Later I found out that occupying them in completing worksheets or involving them in thinking would be better. As I include more activities, they are more occupied (in thinking) and it is better. (Di3)

Another reason for feeling more confident was attributed to being aware of what pupils think:

> I am more confident in teaching. Before I would just read the teachers' reference book, and would not be aware of what pupils think. I would not know what are the ways to correct their concepts or guide them to new concepts.... I now have equal confidence in teaching science as in other subjects such as Chinese and maths. I would not be less confident in teaching science. (E3)

Others (4) felt that they have a sufficient background in science.

> I feel that I have sufficient knowledge in teaching human reproduction. The difficult part is binary fission. I feel that I have adequate knowledge about oviparous and viviparous reproduction. I am confident in the basic parts. I would not feel helpless and don' t know how to teach when I am facing the topic. (C3)

> In addition to what is learnt in the programme and the books from the children' s library, there is almost 80% confidence. Pupils may ask (questions) and I can better explain from the perspectives of the children. For example, pupils may ask how long it takes to

walk around the earth. (I3)

After the teaching practice, the student-teachers experienced gains in confidence with teaching science. The findings from the quantitative measures of the Personal Science Teaching Efficacy Beliefs and the Science Teaching Outcome Expectancy values and those of the interviews are consistent with each other. The change when compared to their feelings before taking the Curriculum Studies was significant (Section 4.5). Better learning of their pupils, more responses, being able to get pupils to think, increased participation, and having control over the pace of teaching have all attributed to the gain in confidence during the teaching practice. Their worry for the subject content lessened. Moreover, the worry about content may not be a genuine concern for the content itself but may also be a reflection of their lack of confidence with the pedagogy as well. It appears that the Curriculum Studies module with its emphasis on teaching science based on a constructivist view of learning has influenced the student-teachers' professional development as well as personal development. The findings in the interviews have also provided some explanations about negative changes or low increase in the Personal Science Teaching Efficacy Beliefs and Science Teaching Outcome Expectancy values in the previous section. These include a perceived lack of academic knowledge and experience in science teaching; the contextual constraints like classroom management; timing for the teaching schedule and in conducting practical activities in the classrooms. While the perceived lack of academic knowledge may be related to the past education experience of the student-teachers, the factors concerning the school and the classroom may be taken as sociocultural factors that shape learning and teaching in the school context.

6.6 Summary

This chapter described the student-teaching experience of the student-teachers in four main areas: teaching science with a constructivist view of learning; science learning in the lessons; perceived problems and influences on the teaching, and feelings about teaching science in school. The student-teachers' concerns during the stage of lesson preparation were more biased towards the school context (like classroom management and pupils' ability). Despite this, their preparations were less bounded by the textbook and the teachers' guide as they reflected before the Curriculum Studies module. They emphasized the importance of discussion with peers during their preparation and the interaction between pupils as they learn in the classrooms. The importance of interactions in their own development and pupils' learning were experienced and valued among the student-teachers. In terms of teaching strategies, the student-teachers attempted a number of strategies that were consistent with a constructivist view of learning. They were ready to consider the preconceptions held by the pupils and in turn adjust their teaching, which included re-arranging the topic sequence, teaching beyond the textbook content, and being flexible in the timing. A number of ways that helped pupils with conceptual change were observed in the lessons. The interactions between the teacher and the pupil as well as those between the pupils themselves, were valued by the student-teachers as supportive conditions for learning.

The improvement in the science learning conditions was more obvious than those in the science learning outcomes. As the teaching practice period was short and that the student-teachers did not have much prior knowledge of the background and ability of the pupils, it was hard to expect significant indications of improvements in learning outcomes. However, the researcher observed that in the lessons, the learning conditions in terms of interest, participation and pupils' engagement were enhanced. Further, the student-teachers reflected on ways to get the pupils thinking, discussing and exchanging ideas in the lessons. Hence, the student-teachers had helped to facilitate the learning of their pupils as they taught science based on a constructivist view of learning.

Both the findings from the Science Teaching Efficacy Beliefs instrument and the interviews were conclusive that the student-teachers became more confident by the end of the teaching practice period. When compared to the situation at the completion of the Curriculum Studies module, the student-teachers experienced further gains in confidence after the teaching practice period. The positive gains in confidence in teaching science is regarded as a form of personal development. It may also be assumed that the experience in the Curriculum Studies module and the experience of teaching science based on a constructivist view of learning helped the student-teachers to increase their confidence to teach science.

The experience of the student-teachers who had little or negative changes in the Science Teaching Efficacy Beliefs values (3 out of 20) may be interpreted as a lack of academic knowledge, insufficient experience in science teaching, and experiences of difficult teaching context during the teaching practice period. Moreover, the problems and influences on the teaching of the student-teachers were identified in the interviews and the science teaching questionnaire. These included: classroom management, concerns about the background knowledge in science and in getting pupils to change their learning habits and be involved in thinking. While it can be interpreted that the perceived lack of academic knowledge is related to the previous educational experiences of the student-teachers, problems in classroom management and pupils' learning habits are the sociocultural factors that influence how teaching and learning is defined in the school or classroom. These two types of factors may both influence the student-teachers' teaching and feelings of confidence to teach science.

The next chapter looks into the experience of the student-teachers after they graduated and began to teach in primary schools.

Chapter 7

The needs of the beginning teachers and the design of the resource packs

7.1 Introduction

In order to find out the development of the beginning teachers at the beginning teaching phase, this chapter describes the views about learning and teaching science among the beginning teachers with an aim to identify their needs for supporting their science teaching. This is an attempt to provide on-going support, which includes a resource pack for the novice teachers such that they may teach science with a constructivist view of learning as advocated in the Curriculum Studies module. The eleven student-teachers who participated in the previous phase of the study had all graduated from the programme and among them three did not succeed in finding a teaching job, while three others taught in special needs schools[1]. The remaining five teachers who participated in the final phase of the study are represented as teachers B, I, L, E and D. The representation used is the same as that in the previous phases of the study. Teachers B and I were teaching in the same primary school but they were teaching different levels for the subject of General Studies.

The student teachers were interviewed three times during this phase. The first interview, which occurred three months after they started to teach, aimed to find out how they teach science in the school, and to identify their needs. Subsequent to the interviews, a resource pack was designed based on their needs and distributed to each of them to support them in teaching a science topic during the second term of the first year of teaching.

[1] The special needs schools are set up for children with special mental and physical needs. The curriculum, the ability of the pupils and the classroom situations are very different from the primary schools.

Drawing on the views of learning and teaching science among the beginning teachers and their perceived needs, the last part of the chapter describes the design of the resource packs.

7.2 Views of science learning of the beginning teachers – the importance of learning science content in the primary curriculum

As in the previous phases of the study, the beginning teachers were asked to describe what they thought was the important aspect for the pupils to learn in science and to compare the relative importance of science learning in the primary curriculum (Section 3.3.2.1). Three of the beginning teachers (teachers B, L and D) related that it was important for the pupils to be able to apply the concepts learnt into daily life situations, for example:

> Science is related to daily life. They know how to handle their problems and that is really common sense, something that they should know. (Lbi1) (Refer to Chapter 3, Section 3.4.2 for a description of the coding)

Learning science in contexts that are meaningful to the students was found to be important and it was left that this could stimulate interactions with the pupils. For example:

> I think the reference to daily life experience is important, for example, the classroom atmosphere is better as I asked them if they had been to the zoo. It is much better than just talking about the textbook. It is boring. The pupils volunteer a lot of information as I refer to their experiences. (Dbi1)

> We also discussed how to prevent fire and pupils have seen the fire extinguisher and the fire blankets around them, they would want to know about these. The discussion about how to use these things and the reasons behind them were interesting for the pupils. (Bbi1)

Adding to this notion of relating to daily life experiences, teacher E indicated that to develop in pupils an ability to observe and be attentive was of importance. He described how the pupils were alert in the lesson:

> They develop the ability to observe e.g. they know how different plants differ in their structure as they live in different places. Why the leaves have different shapes, they can tell how the environmental factors influence the plants. The ways that the plants adapt to the environment. (Ebi1)

Teacher I suggested the importance of enabling pupils to find out new knowledge by themselves as she was impressed by the use of projects in the schools:

> That (The important thing) is to enable pupils to find out new knowledge..... The pupils should be able to find out more information from the library and newspapers etc. The school has designed projects for every class. The pupils have to find out information about natural resources, the problems and the solutions...The pupils learn a lot through this and find out updated information about the topics. (Ibi1)

From this, the beginning teachers viewed science learning with reference to meaningful contexts as important and that the pupils have to be able to apply what they have learnt to make their learning meaningful. Moreover, skills like observation and being able to find out information independently were also seen as important in science learning. These views are consistent with those after the Curriculum Studies module was completed (Section 5.3). In the previous phase, the importance of learning in relation to everyday experiences was highly regarded, while the ability to understand further knowledge and the process skills were mentioned by relatively fewer respondents. Apart from these, the five teachers also recognized learning science knowledge and developing an interest in science as important, consistent with findings in the previous phases. In this phase, the relatively decreased importance of learning science knowledge in the primary curriculum can be explained by the relative unimportance of science as compared to other subjects. Following the low importance of the subject in school, developing an interest in science may become a concern of low priority.

Three of the beginning teachers (teachers I, E and D) regarded the three examined subjects Chinese, mathematics and English as more important than science learning, while the other two thought that all the subjects were of equal importance. The low importance of science learning was explained:

> Yes, I think that Chinese, mathematics and English are more important. This is something enforced by the system. In sending

> marks for the secondary, the languages are more important. The teachers will also pay more attention to the language exam papers than the GS (General Studies) papers. In reality the languages are more important. (Dbi1)
>
> I think that the languages are more important. The scores for the language subjects have double the weighting in the calculation of the final grade. In terms of percentage, GS (General Studies) takes a smaller portion. The parents will also think that the languages are more important. (Same for mathematics?) The score for mathematics is also doubled. (Ebi1)
>
> It is the fourth that is Chinese, English, mathematics and GS (General Studies). This is the same order as in the report cards. The pupils find that they know how to read the text and do not put much importance on learning it (General Studies). (Ibi1)

Though the exercise for calculating the marks for secondary school occurs only in primary five and most of the beginning teachers were teaching at the primary two level, the influence of the exercise was significant enough to influence the teaching and learning of science at all the primary levels. The beginning teachers attributed this influence as arising from the system and was enhanced by the attitude of the parents and the pupils.

In the beginning teaching phase, it turned out that science was a relatively unimportant subject and this influenced to some extent how the beginning teachers regarded the most important aspect of science learning. The development of the view that science is not important among the beginning teachers may be interpreted as being influenced by other teachers, parents and pupils who viewed the relative importance of the subjects in the primary curriculum. Among the beginning teachers, science learning was seen to be linked with meaningful context with particular reference to pupils' daily life experiences. The ability to engage in continuous learning and to be attentive were regarded as being significant.

7.3 Teaching science in school

This section describes the concerns and strategies during the preparation for the science lessons, the teaching strategies that the beginning teachers employed, their descriptions of their successful General Studies lessons, their perceived influences on their teaching, and the support that they received from the schools.

7.3.1 Concerns and strategies during lesson preparation

The beginning teachers were asked to describe their concerns and strategies during lesson preparation. Four of the five beginning teachers (teachers B, I, L and E) reported that they read from the textbook the information about the topic and the dependence on the textbook was stronger than compared with the teaching practice:

> I will see if the information in the textbook can help and I would refer mainly to what is covered in the textbook. (Ibi1)

> I would read the textbook and the materials at the back of the text. After reading the things, I would teach. I don't have time to find out further information. (That means you would read the materials once before you teach. Approximately when will you read the text?) One day before or when I have free periods. (Lbi1)

The beginning teachers did not have much time to prepare for their lessons. They took the textbook as the only source of both information and suggestions for activities. However, both were found to be inadequate, as they related:

> The suggested activities were not very relevant, it was hard to control the pupils. ...(Do you think that the materials in the text are sufficient?) Some of them, for example, the pupils just now asked me about the size of the nucleus, I couldn't answer him. This is not found in the book and I have no idea about this. (Lbi1)

Teacher D found a good collection in the resource room at school but most of the materials were provided by the publisher of the textbook. The teachers hence relied heavily on what was provided by the publishers. Going to the resource room and looking up the information in the textbook became a routine as they prepared for the lessons:

> I went to the resource room to find out if there was something applicable. (Is there a rich collection of resources?) Yes, I think that is already quite good. (What is available there?) There are pictures and for example, there are pictures about oviparous, as pupils have no idea of what it is. This really helps pupils to understand. (Where do the pictures come from?) They come with

> the books from the publisher. (But the pictures are also well arranged?) Yes, there are OHT and pictures systematically arranged. (Dbi1)

The use of the resources provided by the publisher was also indicated by another beginning teacher (teacher L) while she also relied on the materials that she collected during the teaching practice period,

> (You usually have discussion with the pupils during the class.) Yes, discussion and using the pictures in the textbook. It is quite impossible to find pictures big enough for the class, so it is best to use the pictures in the book. Sometimes I would use photos, which are found in the teaching kit provided by the publisher, or some are left from the teaching practice last year. (Lbi1)

Teacher B was more enthusiastic in that he tried to conduct group practical activities in the science lessons, however, the lack of resources in the school made it difficult at times. He finally resorted to talking about the practical activities:

> I would try out the practical activities before the lesson, to find out if there is any difficulty, how to see the results clearly. (Is there other preparation? How do you find the resources in school?) There are not enough resources in school. There should be apparatus like beaker and test tubes etc. In addition, there were no chemicals such as lime water or iodine solution. It is difficult to conduct the practical activities; I have to resort to the textbook or just talk about the practical activities. (Are there other things that you would consider before you conduct a practical activity?) I think that is safety. I let the pupils conduct practical activities using fire. I demonstrate once and let them do it in groups. (Bbi1)

Compared with other beginning teachers, his preparation for these lessons required more effort in trying out the practical activities and in considering the safety precautions. Another beginning teacher (teacher E) used the textbook in a different way, that was by referring to the pictures in the discussion and he had also rearranged the topic sequence in the textbook, as he related:

> Consider what is available in the textbook. There is no time to find more resources, even if I have the motivation, I don't have the time. (Mostly from the textbook?) I consider the sequence in the textbook and may not follow the order. I do not even read the text (to the pupils) but I use all the pictures in it. (Why do you need to rearrange the sequence?) Some concepts are fundamental to others, the order in the book is wrongly arranged. (Ebi1)

By considering the development of the concepts, his view of science teaching was congruent with a constructivist view of learning. However, this consideration was not common among the beginning teachers.

The beginning teachers (teachers D and I) also reflected how they have discussed teaching with their friends or other teachers in the school during their preparation:

> Sometimes I discussed the topic with others. (Who did you talk to?) Friends. (Dbi1)

Apart from discussions with other teachers, information about the needs and abilities of the pupils were found to be helpful, as teacher I related:

> I ask other teachers about teaching the topic like whether the pupils can master the topic quickly or whether they are interested in the topic or not. I judge the pupils' responses and other teachers' advice to decide how much to cover and prepare for the topic. (What is the advice that other teachers give?) Other teachers have told me that the pupils are more familiar with the topic on personal hygiene and that pupils are very interested in the topic on animals. The present topic on policemen (a Social Studies topic in the General Studies curriculum) is very short and it seems to drag for too long, as there is so little to be covered. Other teachers have the same opinion and they said that we can teach it a bit quicker and save time for other activities or topics. (Ibi1)

In summary, the two main tasks in preparing for science lessons involved reading up the textbook and looking up resources in the school. One beginning teacher attempted group practical activities and the concern for the lack of resources was great. For these lessons, the preparation work was to ensure that the lessons went smoothly by having a trial run of the practical activities and considerations about the safety precautions. Redefining the topic sequence with reference to the development of the concept was regarded by one teacher and this may be taken as a consideration influenced by a constructivist view of learning. This occurred less frequently among the beginning teachers than when compared with the teaching practice stage. Moreover, the discussions about teaching with other teachers in the school were perceived to be helpful for the beginning teachers.

7.3.2 Teaching strategies that were employed

The beginning teachers were asked to describe in the interviews the teaching strategies they employed in their science lessons for their first three months of teaching. Two of them (teachers L and D) reverted to more frequent use of teacher-talk in their science teaching. They gave up the use of group discussion and activities despite the fact that they believed these were strategies that helped pupils' learning. For example:

> In group discussions, they would talk about things that are irrelevant to the topic. (Would the textbook also provide the discussion guides or cards?) I would use the discussion cards as in the teaching practice in the beginning, but the pupils were talking among themselves. The cards do not help. It then becomes discussion with the whole class. (Lbi1)

> Many of the pupils come from Mainland China and they have pictures of many animals like panda, giraffe. They are very happy as we look at the photos. There are such a lot of photos. This provides an opportunity for them to talk about their experiences...I am more aware about two-way communications than one-way. For example, I know that increasing pupils' participation is important. However, time is limited as I have seven periods a day, there is really no time for lesson preparation. The teaching schedule is also very tight. Time is so limited that I may not be able to apply what was learnt. (Dbi1)

These two beginning teachers had different reasons. Teacher L had a classroom management problem as she could not keep the pupils on task to discuss a certain topic, while teacher D related a lack of time for preparation and the heavy workload. However, both were aware of the importance of getting pupils to discuss in lessons and valued the "two-way communication".

These beginning teachers found themselves unable to apply what was learnt in the Curriculum Studies module in the primary school. Teacher I related her dilemma between her belief with a constructivist view of science learning and the classroom situation:

> Some of the contents of the CS (Curriculum Studies) module are more influential on my teaching. (Which are those parts?) Like the part about teaching science based on constructivist view of learning or those concerned with finding out pupils' preconceptions. I raise questions for pupils to think and try to change their concepts. I also hope that pupils can be more active in their learning. I also attempted to find out pupils' preconceptions

> on a topic like asking them how much they know about a certain topic. (What is the effect of teaching?) It is more interesting and I find that there are approaches to choose from. There are teachers that make the lessons very boring and the pupils do not like the lessons. (Are there other benefits besides raising the interest of the pupils?) I think that the teacher is more confident and there is "something" to refer to or rely on. The teacher also knows where he/she stands in the various approaches. (Do you think there is any change in the pupils' thinking?) Pupils learn from others' responses and know that they themselves may be wrong. I have seen progress in their learning. Not only the teacher talks or teaches, the pupils feel that they can also raise their hands and talk and teach others about the topic. Knowing that what they have learnt is useful, the pupils are more ready to raise their hands to speak, and the atmosphere is more lively. (Ibi1)

Teacher I was glad about finding out pupils' preconceptions, as she found her lesson more lively and herself more confident. She felt proud to compare with other teachers as they delivered boring lessons. The influence of the Curriculum Studies module was significant, however, the application of the learning into the classroom situation was not as successful in one of the classes she taught:

> In the primary five class, only a few of them are listening to me and raise their hands during the lesson. They feel that they know everything already in GS (General Studies). The pupils think that they can revise on their own...When I called upon a pupil to answer a question, the other pupils were doing their own work...The pupils do not see the relevance of the lessons and feel that they know a lot.....They got less attentive when there were activities in the lesson; I am very angry with them and feel that I do not deserve this reaction from the pupils. Now I would still use some of the materials in the teaching kits (that were prepared during the Curriculum Studies module) and the lesson would be mostly devoted to questioning. (What is included in the teaching kit?) The OHTs (overhead transparencies) and I tended to show more at the beginning of term. As this involved a lot of movement in the classroom e.g. drawing the blinds, moving the desks, switching off the lights, I have used it less and less recently. I would just refer to the pictures in the textbook. (Ibi1)

From this quotation, the beginning teacher related how she was unable to motivate the pupils to learn and help the pupils see the relevance of the lessons. Moreover, there were limitations imposed by the physical conditions of the classroom. The conclusion was to continue with the questioning in class. She finally resorted to a compromise involving giving up on the discussions but continued with teacher demonstrations:

> It depends on the nature of the topic. The next topic is on heat and there will be practical activities. For this topic, as there are a set of

> practical activities to be conducted, I don't need to prepare a lot of activities or materials. I will not conduct any discussions with the pupils, I am afraid that the discipline will be hard to control. I have tried to conduct discussion with my primary five pupils and they cannot really concentrate on talking about the topic. So it will be worse for the primary two pupils. I will do some demonstrations and the pupils can come out and watch the practical activities. (Ibi1)

Teacher D reflected on how her intentions in teaching were different compared to the time before graduation. Due to the limitation of teaching time, she resorted to a transmission approach in teaching, not caring if pupils were learning in the lessons:

> I was very idealistic before graduation and would want to let the pupils find out by themselves through the activities. But now I rely on my mouth and this is the only way to teach. Just tell them. Before that, I would think about the activities and let them see the result. This is not possible now; the time is putting a lot of pressure on me. Though I know it is better to teach in another way than just telling them, I cannot help it. (Have you considered that pupils may not learn even after you have told them?) Yes, but there is no way out. I cannot care. (It may just be the same as if you had not told them.) I cannot help this. (Dbi3)

Two other teachers B and E found themselves in less difficult situations and were able to teach science based on a constructivist view of learning to some extent. Teacher B related a mixture of different approaches in his teaching. He reported the use of the discovery approach, an approach that gets pupils to find out new concepts to be learnt, while he mentioned the checking up of pupils' preconceptions in his teaching. The use of activities and group work were also mentioned to be common teaching strategies:

> I use discovery usually. (What did you actually do?) Asking questions. Find out how much the pupils know before the lesson, usually at the beginning of the topic. (What did you ask, can you give an example?) I asked them the relationship between burning and the use of oxygen. Many pupils think that when there is air, things will burn. I have to let them know that air only helps burning, there are other essential factors like the materials, fire or spark. (Are there other strategies?) I use activities because just talk and chalk is really boring...This is more impressive[2] for the pupils. They forget if they just watch the demonstration but if they

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[2] The word "impressive" is a literal translation of the word that the beginning teacher has used. The meaning is having an impact on the pupils.

> have done it themselves then they have a deeper impression. (Bbi1)

Among the teachers, only teacher E reported to have taught science based on a constructivist view of learning as he described following up pupils' answers and ways to encourage pupils to think:

> I think that I am using an interactive approach. I followed up pupils' responses and asked them why and they responded again.... (What do you think of the response of the pupils? Can they really think in response to your stimulation?) Yes, most of them can. I can make them think. (Would it be difficult?) Yes, some of them don't really want to answer. Some are not ready to think or are afraid to be wrong. (Is this common?) There is a good proportion of them. For the smart ones, they would race to answer, for others, it varies. (Do you encourage them?) I would use rewards and competition to encourage them to think. I would also discourage others who laugh at wrong answers. (Do you think there is improvement?) Yes, there is a little bit, more pupils are ready to speak up. (Ebi1)

From this, teacher E valued pupils' responses, followed up on pupils' answers and encouraged them to think and speak up in class. Among five of the beginning teachers two (B and E) were aware of engaging pupils in thinking, and two (B and I) attempted teacher demonstrations or group practical activities with pupils. Others (I, L and D) spent most of the time having whole class discussions that involved the teacher asking and pupils answering questions. The beginning teachers were aware of the teacher-pupil interactions during questioning and pupil-pupil interactions during group discussions in the classroom, as well as the implications of a constructivist view of learning for science teaching.

7.3.3 Science lessons described in the journals

As one of the ways to enhance the beginning teachers in teaching science with a constructivist view of learning was to provide on-going support, the needs of the novices had to be identified such that the design of the support may better suit their needs. In identifying their needs, each of the beginning teachers were invited to describe in the journals three General Studies lessons that they felt were successful in their first three months of teaching (Appendix B1). In this way, the researcher may have a better understanding of the purpose or intentions of the beginning teachers in their science teaching. Unlike section 7.3.2, which describes what teaching was like in most of the science lessons generally, this section analyses the more successful lessons as reported in the journals. In this way, the researcher can be clearer about what the beginning teachers thought better science teaching needs to be like. In some cases, the quotations in the interviews are used to clarify what the beginning teachers had written about in the journals. These lessons often included activities, demonstrations and group activities. Above all the use of pictures to facilitate whole class discussions was the most common as four out of five teachers (I, L, E and D) have reported lessons as such.

The beginning teachers described how they used class discussions or teacher questions and using simple teaching aids to stimulate pupils to ask questions in the lessons:

> I raised questions using the pictures in the textbook. The pupils were able to organise what they know and this leads them to realize how animals are classified; the services and the resources they provide. (Ij1) (See Chapter 3, Section 3.4.2 for a detailed explanation of the codes)
>
> At the beginning of the lesson, I showed the electricity bills and asked the pupils what they were. This leads the class to discuss about what are natural resources are. The lesson went on with discussion, conclusion with the whole class.
> They asked a lot of questions in the lesson but they actually knew what are natural resources were already.
> Teachers' reflection:
> I am satisfied with this lesson. After the lesson, the pupils were able to distinguish what natural resources are and I have used an interactive approach in teaching. The bills have stimulated the pupils to start thinking. I hope to have more teaching aids to support my teaching, as there is really a lack of teaching aids in GS (General Studies). (Lj1)

The above illustrated how the beginning teachers tried to stimulate pupils to discuss and think about the science topic using the limited resources available and within the constraints of classroom management. The use of pictures stimulated the pupils to ask more questions in teacher D's science lessons:

> Pupils have quite a good response, the pictures are about something that they can see in their daily life experiences, and this

> can stimulate interest for most of them. Some asked if frogs are poultry. ...The pupils have a lot of questions to ask e.g. they ask why are tadpoles black in colour and frogs are green. They are very interested in this topic. (Dj1)

Teacher I gave an account of a successful lesson, in which she used a set of drawing cards that she had prepared in the teaching practice a few months ago:

> Method of teaching: An activity that involves drawing cards of animals and imitating the calling of the animals was conducted with the whole class. It is more interesting to talk about animals and the lesson is very lively. The activity was not in groups and so pupils' involvement in thinking and discussion may be limited. The pupils have a lot to ask in the lesson and are different from the normal situation. (Ij1)

From this, she preferred to have group discussions though the pupils asked a lot more questions than they normally would.

Teacher B was keener on having pupils' participation and employed group discussions and activities:

> There was a group discussion about the sources of air pollution. The pupils participated actively and were able to tell sources. The teaching pace was comparatively slow as one lesson covers only one objective.
> I believe that this is effective, as the pupils were able to relate it to their own daily life experiences. Also, the pupils were actively involved in thinking. (Bj1)

> There was a practical activity to test that the air breathed out is carbon dioxide (using drinking straw and limewater). At the beginning of the lesson, I demonstrated the experiment and reminded the pupils about the safety precautions. Then, I let the pupils try to do the experiment and find the conclusion by themselves. This activity has encouraged the pupils to relate the results with daily life experiences.
> Pupils valued the opportunity to do the experiment and were attentive to my explanation.
> After the experiment, the pupils were very surprised to see the results.
> The pupils raised a lot of questions.
> The lesson is satisfactory as most of the pupils were on task. (Bj1)

These were experiences that teacher B regarded as successful because the pupils were participating and thinking actively. They were able to relate the results with their daily life experiences and raised a lot of questions. However, teacher B also noted that the teaching pace was slow. Because of the tight teaching schedule, conducting lessons with group activities or discussions was not frequent among the beginning teachers.

Three out of five teachers (teachers I, L and E) related concerns in teaching that were made based on a constructivist view of learning. Teacher I described how she found out pupils' preconceptions about animals:

> There are different types of animals and the pupils do not know about the relationship between the animals and humans. They are more familiar with the functions of the animals in relation to entertainment and do not realize the original functions of the animals. (Ij1) They know that dogs are kept domestically but do not realise that there are watchdogs. They do not know that horses are for transport and only think that they are for racing or gambling or entertainment. (Ibi1)

Having learnt the pupils' preconceptions, teacher I tried to adjust her teaching according to what the pupils knew:

> I am happy with the teaching in this lesson because I tried to look into how many pupils know about the animals through asking questions. I did not have detailed plans for this lesson but I have tried to adjust my teaching according to what the pupils knew about animals. (Ij1)

Teacher L indicated how she attempted to clarify pupils' concepts during her teaching:

> On the whole, I am satisfied with the lesson, I think that the pupils can learn well from the pictures but that some of the pupils do not have a good foundation. I clarify with them in the following lesson and they are clearer. I have been using the interactive approach in this lesson and pupils were stimulated to think using the pictures. (Lj1)

Teacher E mentioned these views more often than the other two beginning teachers. He explained how he considered what pupils have learnt as he prepared the lessons:

> Preparation before the lesson: The pupils have some understanding about the self-rotation of the earth, but do not know about the direction of self-rotation and the relationship between day and

> night. I then prepare to bring a globe, a plastic doll and a torch for the experiment. (Ej1)

He described how the pupils had different preconceptions, their diverse abilities and how their preconceptions influence their learning of new concepts:

> There is much individual difference among the pupils and the high achievers have very good responses and can answer most of the questions. The low achievers did not have any responses and could not tell what they did not understand.
> Reflection:
> This particular method has helped to stimulate the pupils who are not motivated to learn and have difficulty in learning. However, at the end of the lesson, some cannot master the new concept. Pupils' preconceptions or misconceptions may influence how they learn new concepts.
> In this lesson, the use of pictures and discussions can stimulate pupils to think. (Ej1)

From the accounts in the journals, teacher E had related detailed considerations for the constructivist view of learning in his science teaching. Teacher B was enthusiastic in conducting group discussions and group practical activities believing that the activities helped to engage the pupils to think actively. Though teachers I, L and D did not conduct group discussions in their classes, they valued the response and participation from the pupils. While teacher D seemed to be satisfied with having more questions from pupils, the other two teachers I and L hoped to see further improvements in their teaching. They felt the need to have more resources to support their teaching and still preferred the use of group discussions. These two teachers were also ready to adjust their teaching content according to the pupils' preconceptions and helped pupils to clarify their concepts. It is apparent from these accounts that the beginning teachers had in mind the constructivist view of learning, though due to a number of influences in the school context, they were not able to teach in much the same way as they did in the teaching practice.

7.3.4 Influences on the teaching of the beginning teachers

In order to find out the sources of influences on the teaching and the confidence of the beginning teachers, they were asked to describe events or factors that influenced their teaching, in the interviews and in their journals.

Limited time for teaching and lesson preparation, insufficient resources, and classroom management were the most frequently reported influences (Table 7a). Teachers B and E related that the teaching time was cut short by school activities and that the teaching schedule was tight:

> There are only 35 minutes per lesson, it was 40 minutes before (during the teaching practice). Most of the GS (General Studies) lessons occur after recess, some time is used in letting the pupils settle down and gain their attention. I can achieve only half of the objectives. (What is the teaching schedule like?) There are a lot of school activities like the 15th school anniversary and some lessons were cancelled. I teach in a great hurry. (Bbi1)
>
> The whole topic for moon eclipse takes only 7–8 lessons and even so there is not enough time. In the teaching practice, we have more time for lesson preparation and the pace is more relaxed. (Ebi1)

Table 7a Influences on the teaching of the beginning teachers as reported in the interviews
(N=5)

Perceived influences	Teacher(s)
Time and resources	
Time is limited in the lesson	B, E, D
Have to reserve time for revision	D
Less time available for lesson planning or preparation	L, E, D
Heavy workload and little time for preparation	I, L, E
Classroom setting makes it difficult or inconvenient to use OHP	I
Resources are limited	E
Pupils	
Classroom management	B, L, E,D
Pupils' attitude in learning	I
The School Context	
Value for good achievements in examinations	D
School does not support activities or visits	E
How other teachers think	E
The norm is to have little preparation for lessons	E
Self	
Was not aware of pupils' problems in learning	I
Teaching pace was too quick for pupils	I
Inadequate lesson preparation	I

Teachers L and D reflected on the heavy workload and how the preparation time was different when compared to the teaching practice:

> Less time is available for lesson preparation; I spent two to three hours to prepare for one lesson during the teaching practice. This is impossible now. I can take at most fifteen to twenty minutes to prepare for a lesson. I would just read the content and think about the teaching. There are a lot of books to mark and I take the worksheets home to correct. In addition, there is a lot of administrative work. (Lbi1)

> The pressure is great after the lessons, as there is a lot of work. The teaching schedule is another thing that gives me pressure. (Is there any difference in the teaching method?) Teaching aids and activities are included only when it is absolutely necessary. Otherwise, I do not waste time on these. (Dbi1)

These teachers faced a heavy workload and little time was available for lesson preparation.

The second major group of factors influencing the teaching of the beginning teachers was associated with classroom management and the ability of the pupils, as two teachers L and E described:

> I teach in a completely different way when compared with the teaching practice. The pupils would still discuss though they are noisy. Now many things happen during the class. Someone may cry, others may complain about their classmates, it is difficult to manage the class. It is different from the teaching practice, they are not used to having discussions in class, and they will talk among themselves. (Lbi1)

> They get too excited with a little bit of activity, the discipline is not controllable and the lesson cannot be conducted. The class that I was teaching was really bad. (Ebi1)

The teachers (I and L) have also expressed their frustration with the classroom management problem. They described themselves as being less motivated and felt tired about teaching:

> As the pupils do not like the subject themselves, I feel that I cannot help them too much. I would be more willing to prepare more for the primary two pupils. I was more enthusiastic at the beginning, trying to think about what I should teach and how to make the pupils happy. It then gets to be a bit boring and I feel myself becoming less enthusiastic. The workload is too heavy and I find it really hard to find time to prepare so much for the lessons. It is

> more worthwhile if the feedback from the pupils is more positive but then as it is not, I feel less motivated. (Ibi1)
>
> It is mainly discipline. If it gets too noisy, the pupils cannot learn. I have to repeat several times...They are very noisy especially in my lessons. Several pupils were particularly noisy and this influences the whole class. (How did this affect you?) As they were not listening, it would take more time to teach the topic and slows down the pace of teaching. I have to repeat myself several times...I do not really know what to do (laugh). I feel really tired. (Lbi1)

The discipline problem and low level of interest among the pupils, and the heavy workload contributed to the beginning teachers' loss of motivation to teach. The school context and the practice of other teachers also had a significant influence on the teaching of the beginning teachers as two of them (E and I) explained:

> The school does not encourage the activities. I have suggested taking the pupils out for some visits and was not supported by the school. (Do you think this is the attitude of the teachers?) This is understandable as they have a lot of duties. Teachers do not only teach, there are a lot of administrative duties. They are not ready to use the holidays for the visits and if they go on school days, it would affect the teaching schedule. There is one visit per year and this is really scarce. There are two science topics per year e.g. plant and space. It would take two visits. (Ebi1)
>
> Yes, the atmosphere affects the availability of teaching aids in the school. Without the resources, the activities are not possible. If other people were not using the things, they would not be arranged in good order. It would be difficult to retrieve them. (Ebi1)
>
> Resources are also limited and I tend to accept that many teachers do not prepare for their lessons. It is just similar to the norm. The more experienced teacher can seek help from the workers in the school or ask the upper primary pupils to prepare for the lower primary. (Ibi1)

These quotations indicate that the beginning teachers gave up their original intentions and considered the practice of the more experienced teachers in the school. The existing practice has influenced the teaching of the beginning teachers through direct and indirect ways like the availability of resources and the culture for not doing much for lesson preparation that the teachers have developed. The teaching culture in the same school also implied that the value or importance in teaching was to have good achievement in examinations, and this led to the adjustment of the teaching pace as related by teacher D:

> Pupils' achievement is more important. I would rather teach at a quicker pace and leave some time for revision. If there are activities, there will not be time for revision. (Dbi1)

The influence of the culture in the school has resulted in the cutting down of activities in the lessons in order not to make the lessons too different from other classes:

> I would avoid some of the things and decrease the activities as I cannot prepare so much, and other classes may not have such activities. (Ebi1)

Another beginning teacher justified the change in her teaching strategy as being free from the constraints of the requirements of the Institute:

> It is more relaxed now. I can teach in whatever way I want. There were different steps before like the motivation, development, conclusion, etc. Now I am making full use of the 35 minutes to teach. There are a lot of other things to do in the lesson. (Why do you feel more relaxed?) I worried if my teaching is good enough in the teaching practice. I consider if the question should be asked in a certain way and if the pupils can answer my question. But now, the development is more natural and follows the response of the pupils. (Dbi1)

In this situation, the lack of consideration about the quality of teaching and the use of most of time in the lesson in transmitting content was thus explained as following the norm or the practice of other teachers in the school. The beginning teachers shifted from being influenced mainly by the institutional culture to be under the cultural influence of the school. The school culture was defined by how other teachers were teaching and the school practices, which were different from what was taught in teacher education institutes. Another beginning teacher I, however, realised the problem in science teaching from a different perspective. Instead of only focusing on the problem as originating from the school, the workload and the pupils, she was aware of her own limitations. She reported an incident to illustrate how her deficiency in the background understanding about the pupils led to an unsuccessful lesson:

> I did not have adequate preparation and underestimated the difficulty of this topic. It turned out to be difficult. I had too high expectations of the pupils' ability, and the reality is I also had to cover the basics. (Your estimation of them is not accurate.) The

> other topics are better and I do not expect it to be like this. This also happened that the pupils could not follow after I have taught for one lesson. I have to teach from the basics in the second lesson. I have more detailed plans after that. I would at least mark down how to teach the topic. (Ibi1)

From this experience, teacher I realized the importance of lesson preparation and gave more careful thought to how the topic should be taught.

From the findings, it appears that the beginning teachers were able to identify a number of influences on their teaching. The most common ones were the limited time for teaching, lesson preparation, constraints on resources, and difficulties in classroom management. The influence of the school culture was described as the norm of having little preparation for lessons. The beginning teachers abandoned some of their original intentions and tried to make their teaching not too different from other teachers. The importance shifted towards attaining good achievement in examinations and the value of the practice advocated in the teacher education programme was lowered. Despite this, one of the beginning teachers was being more self-reflective and realized the inadequacy of her lesson preparation and how it affected her pupils' learning. On the whole, teaching in school was a different scenario compared to the time of the teaching practice, and the contextual influence of the school was significant.

7.3.5 Support received from the school

The beginning teachers were asked to describe the support (if any) they received from the school as they entered into the profession. At the school level, none of the teachers reported any formal form of support in the interviews. One of the beginning teachers explained what other teachers thought about the novices:

> There is no support (laugh). They feel that we are very competent as we have just graduated from the Institute. We should have known a lot after studying for two years and in fact, we know more than the other teachers do. For example, we are clearer about the new initiatives of the Education Department like TOC[3] than the experienced teachers. They ask me about these policies. (Dbi1)

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[3] Target Oriented Curriculum, a new curriculum initiative for the three main subjects Chinese, English and mathematics in which achievement targets are set for pupils at different performance levels.

This may imply a lack of in-service teacher development opportunities and that beginning teachers were regarded to have more up-to-date knowledge. The support for the beginning teachers was often more informal among teachers themselves, for example, two of the beginning teachers described their discussions and sharing with more experienced colleagues:

> Other teachers of the same level have helped me to scold the pupils and the discipline master is also aware of this. The pupils are more respectful to their class mistress...(Besides helping you with the discipline, are there other forms of support?) Not much. (What type of support do you think would then be helpful?) It is hard to ask for others to help me as all the teachers are fully occupied. (Lbi1)

> Other colleagues have given me a lot of support; they helped me with the discipline. They shared with me the experience in teaching; for example, they would remind me about the wrong words in the books, the common mistakes made by the pupils. There is a meeting in each school term where we would discuss the likely problems and this sharing between teachers is helpful. (Ebi1)

The beginning teachers perceived both the direct support by helping the novices to control the class and the indirect support by sharing teaching experience as helpful. The beginning teachers appreciated very much the support from the experienced colleagues. However, they would not demand further support as they found that everyone was fully occupied.

7.4 Feelings about teaching science in school

This section looks into the beginning teachers' confidence in teaching science and how they feel about teaching science in school. These findings may provide a picture about their personal development as they started the beginning teaching phase.

7.4.1 Confidence in teaching science

The beginning teachers were asked to describe their feelings about having to teach science topics in General Studies and how they perceived their future development in teaching science, in terms of teaching skills and confidence. It appears from the findings in the interviews with the beginning teachers that the confidence to teach science topics among the beginning teachers was closely linked with their concern for the academic knowledge that they had. For teacher B, the confidence to teach depended on factors like the time available for lesson preparation and the nature of the topics:

> Time is limited for lesson preparation. Sometimes when pupils asked me "strange" questions about the topic, I could not answer. If they ask things outside the text, it is difficult. There are things that I do not know. (Bbi1)

The beginning teachers described how they worried about answering pupils' questions and not being able to explain the content clearly:

> There is no problem with the lower primary, the easier topics, however I worry for the more difficult topics. That depends on the topic. (Dbi1)
>
> Just average (In what way?) Sometimes, I cannot answer pupils' questions. I do not know how to explain to them how nuclear energy is formed. I have to ask other people about this. (Is it mainly with the content?) Yes. For example, with producing energy from water, I remember a practical activity in my lower secondary that uses water and carbon to light up a bulb. The memory is vague and I cannot relate clearly how the energy is produced to my pupils...as I have an arts background, it is difficult for me. I am better with Geography than with science topics. I would read up more if I had time. (Lbi1)
>
> I find some of the things quite difficult. It depends on the topic. When it is about animal classification, I am not very certain about how to classify them and feel that I am not as confident. There are also more difficult topics like heat. I don't think that I have learnt the topic properly and I am not as hard working in reading reference materials. I am a bit afraid. The information in the text is not very detailed. I can only teach based on the limited knowledge that I have and maybe with the help of a little bit of material from the text. My confidence depends on whether I have good knowledge about the topic. (Ibi1)

These beginning teachers had an arts background and the problem with the science content was aggravated by a lack of time for preparation. Among the five teachers, only teacher E was more confident with his background knowledge in science as he said:

> For most of the topics, my knowledge is sufficient. There is a small proportion of topics that I may need more information on e.g. just now when the pupils asked if there is hair on the leaves of the Banyan tree, I don't really know about that. (Ebi1)

The findings reflected a uniform concern among the beginning teachers: the adequacy of the background knowledge in science. This is the sole criterion against which they measure their confidence to teach science. Unlike the findings in the previous stages during the teaching practice, the student-teachers felt more confident in being able to engage pupils in thinking, getting pupils to participate and respond to questions (Section 6.5.2). The beginning teachers shifted their concern merely to transmitting the clear concepts to the pupils. This may be explained by the situation that the examination achievement is the greatest concern among the teachers in the school culture. Thus teaching the subject content in a more transmission way was seen as the most common and effective practice in schools and there was little concern for engaging pupils in thinking.

7.4.2 Being a science teacher in the school

The beginning teachers compared how their science teaching was different from other teachers in the school in the interviews. The use of activities, group works, and teacher demonstrations were found to be uncommon, as they described:

> They (Other teachers in the school) are not really taking an activity approach. Even the subject coordinator is just doing talk and chalk. For example, in a lesson about the characteristics of plants, the subject coordinators showed a leaf and then told the pupils everything himself. He then asked the pupils to pass out the leaf. I think he should let the pupils work in groups, look at the leaf and think. It is important that the pupils touch, feel and think about the topic. (Bbi1)

> It is just different with the topics that involve practical activities. They will not conduct any activities in their classes. (Dbi1)

> They would use things that are already available e.g. the picture cards from the publishers. They seldom make any teaching aids or add anything to the lessons. Though I do not have much, it is comparatively more than what they have. (Do you think other teachers appreciate what you have prepared?) They think it is good and they know that there should be activities and how to teach. However, there is a lack of time and resources. (Ibi1)

From this, teacher I thought that other teachers knew about how to teach science and their actions were mainly due to a lack of time and resources. However, other beginning teachers found a difference in their basic beliefs about science teaching from other teachers in the school:

> Other teachers put more emphasis on getting the pupils to memorize the text. They would insist on the same wording as the textbook for the answers in tests and examinations. (Answer in lower voice) I think that my pupils should get some marks, as their answers are correct though the wording may be different. It is a subject that is different from Chinese and English. Some teachers do not see the essence of the subject GS (General Studies) in making pupils to understand. (Lbi1)
>
> Maybe that is why my class did not perform so well in examinations...The question is asking the pupils to fill in the terms found in the text. The pupils do not know how to write the words. The problem is that I did not drill the pupils to write the words like we do in Chinese. There is such a part in the paper. (Dbi1)

These quotations suggest that getting pupils to memorize the text and drilling for the terms were common among other teachers, while the beginning teachers did not agree with these practices. The teachers in the same school did not have many discussions among themselves about their teaching method or strategies. For example:

> (Did the teachers discuss how to teach a certain topic?) Very rarely, unless it is for very difficult topics. They give some advice but that was limited. (There are little opportunities to prepare for lessons together?) Not much. (Ibi1)

The difference in the teaching between the beginning teachers and other teachers was significant enough to show up in the examinations or tests. The pressure to get pupils to score good marks in the examination was great. The beginning teachers found themselves emphasizing thinking and understanding while other teachers stressed having the exact wordings as the textbook in the examinations. As the assessment was geared to test for memorization, their pupils did not perform well since they did not do the writing drills and the recitation of the text. The beginning teachers thought of different ways to tackle the situation:

> Though I do not want to, I have to get the pupils to write the words in GS (General Studies). (Is this something to do with the teaching or the assessment?) That is not a problem with the assessment, the

> pupils should not be illiterate, they should be able to write down what they know. (You feel that they should be able to write these.) They should, otherwise, they are illiterate. (Dbi1)
>
> Normally, I do not pay too much attention to the text as I teach. But then in the revisions for the examination, I will use more time to go through the text with them and pay attention to the words. (Do other teachers teach differently then?) I think so. (In a low voice) They will emphasize the words and the text. (Dbi1)
>
> I would adjust my marking (laugh). If I think that the pupils have answered correctly, I would mark them as correct. I discovered this as I was setting the paper last time. The panel chair asked me whether I accepted pupils' answers if the wording was not correct. She remarked that I was quite loose in my marking. (Lbi1)

Teacher D chose to conform to other teachers and gave the pupils drilling on their writing. Moreover, the pre-test or pre-examination revisions were found to be important in preparing them for better scores. Teacher L adjusted her marking and awarded pupils some marks even if they did not get the exact wordings correct. Other beginning teachers reported on how they insisted on their own teaching strategy:

> I think it is mostly the same. Most of the teachers will follow the textbook and it is the same with me. Occasionally, I will arrange activities; I have not seen other teachers teaching. Sometimes I also get bored. (Ibi1)
>
> The new teachers would use more activities and practice what we have learnt. They (the experienced teachers) have taught for a long period of time and have lost their enthusiasm. (What do you think?) I was disappointed. For science topics, we need the activities and need the pupils to think. (Is there any influence on you?) I wonder if they know how to teach GS (General Studies). I would insist on my way, to have participation, to have activities or discussions. (Bbi1)

These two teachers (I and B) continued to include activities in their teaching with an aim to make their teaching more interesting. This also reflected their enthusiasm in getting pupils to think and participate in the lesson. Teacher L described how she made her pupils think in class and how she re-directed the focus of the assessment on one occasion:

> I once set a table in the test that the pupils could not answer. It demands more reasoning from the pupils; the topic is on the influence and effect of the lack of a certain type of resource. The same table also appears in the textbook. When I teach my class, I encourage them to think, drawing from their common sense. They (other classes) cannot answer, maybe they have no experience of

> doing similar problems before. Even the best class could not do it, however, some of the pupils in my class knew how to do the problem. (Lbi1)

Although the beginning teachers have attempted to teach science based on a constructivist view of learning, they also reported on how they may have conformed to the accepted practice or the culture in the schools. Teachers L and E predicted how they may teach in the future:

> I have asked the pupils to write the words, I modify it into copying the main points. This is better than writing just words, it is more meaningful. (Does this change what you believe?) It may (laugh), some day I may ask my pupils to recite their text. Their results are poor and I need to submit the results to the school. (Lbi1)

> The difference is not that great. They (other teachers) are also reasonable, as the pupils cannot adapt to other methods of teaching (teaching with more activities). It would be equally problematic, as pupils cannot adapt to new teaching styles...I would rather not teach in that way (using activities). (Is it because of the class discipline or other teachers?) The problem with the pupils is more serious and you can teach in whatever way you like as the door of the classroom is closed. The ability of the pupils is more important. (Ebi1)

The pressure to score high marks in the examination and to have the classroom well under control has influenced the teaching of these teachers (L and E).

In summary, the norm among the teachers in the school was to have few activities in lessons and an emphasis on memorization. However, the beginning teachers noted the difference in their teaching as being more ready to arrange activities for the pupils and to demand more thinking from the pupils. The beginning teachers had chosen to keep up with their belief and to get around the problem of low performance in assessments. Further, there were concerns among the beginning teachers of not being too different from other colleagues in the school. These teachers may eventually conform to the practices in the school. The contextual influence in the school was taking effect and may have a greater impact on the teaching of the beginning teachers in the future. It is, therefore, important that the beginning teachers receive additional support in their science teaching so that they can keep up with the practice that takes into account pupils' thinking.

7.5 The perceived needs of the beginning teachers to support science teaching

This section reports on the support that the beginning teachers would have liked to have had in their science teaching. The findings were taken from the interviews with the beginning teachers. The support preferred by the beginning teachers could be categorized into two types. The first group involved the provision of resources, teaching aids and reference materials, such as:

> More examples and teaching aids will help the pupils to understand better. There is a lack of these. (Lbi1)

> The most important thing is resources. The beginning teachers have a good grasp of the teaching strategies, there is no problem with this. The problem lies in the resources available. This affects our teaching e.g. there is no limewater in the school. (Bbi1)

> More teaching aids will be better...It is good to have some worksheets with contents that relate to daily life. For example, using the menu from a restaurant to design a worksheet would be interesting. (Dbi1)

> Reference materials on special topics. I would worry about some topics like the eclipse of the sun and the moon in primary six. Though these are covered in the books, it would be better to have more...though I learnt these topics are learnt in the Institute before, I have tended to forget them. If the materials are there, I can always refer to them. (Dbi1)

The availability of the materials could make the teaching different and this directly addressed the problem of lack of resources in schools. The need for reference materials was consistent with the beginning teachers' perceived lack of background knowledge in science, which led to a lower confidence in teaching science. Moreover, teacher E suggested that making the worksheets or materials convenient for the teachers was important:

> The teaching aids and the suggestions for the activities are important. I can modify the activities. Those like observing pictures are not useful. The worksheets are also helpful. (However, you have mentioned that other classes are not using worksheets.) We are not using them because the teachers have to design the worksheets; it would be different if the worksheets were readily available. The teachers may consider using them if they were already there. (Ebi1)

This directly addressed the problem of lack the of time for preparing extra materials for the science lessons.

The second group of support that the beginning teachers mentioned was related to collegial support in the schools:

> Another thing is that we need to know what other teachers are teaching at the same level. (Bbi1)
>
> Teachers of the same level can group together and look into the lessons in more detailed ways. They do not need to rely on what is supplied by the publishers. The teachers can produce the teaching aids and share them with other classes. (Ibi1)
>
> Other colleagues have given me a lot of support; they helped me with the discipline. They shared with me the experience in teaching; for example, they reminded me about the wrong words in the books, the common mistakes made by the pupils. There is a meeting in each school term where we discuss the likely problems and this sharing between teachers is helpful. (Ebi1)

The beginning teachers perceived a need for joint effort in lesson preparation, to have a knowledge of how other teachers taught in their classrooms and to have opportunities to share their teaching experience with other teachers in the school. The interactions with other teachers in the process of learning to teach and in preparing for teaching was one of the concerns among the beginning teachers.

Drawing on these two groups of needs, namely, the need for resources, teaching aids, reference materials and collegial support or social support, the support for the beginning teachers was designed. These included support in the form of providing a resource pack, an introductory workshop and opportunities for inquiries to the researcher.

7.6 The design of the resource pack

This section describes the design and the content of the resource pack and the supporting activities during the beginning teaching phase of the study. The researcher designed the resource pack and the supporting activities with the following purposes in mind:

- to support science teaching based on a constructivist view of learning;
- to support the beginning teachers' concerns for lack of time and resources in their science teaching;
- to facilitate the development of the beginning teachers with social support;
- to help the beginning teachers to reflect on their science teaching as they used the resource pack.

Two resource packs were produced, one on the topic "heat" for primary two pupils and one for the topic "the body" for the primary four pupils. These topics matched with those that the five beginning teachers were going to teach in the second term of the school year.

7.6.1 Support for teaching science based on a constructivist view of learning

The main purpose of the resource pack was to support science teaching with a constructivist view of learning. In order to achieve this purpose, the researcher chose the contents to be included for the two topics; "heat" and "the body" based on the following criteria:

- to allow the beginning teachers to re-think the topic sequence that facilitates pupils' conceptual development;
- to provide information about children's preconceptions;
- to include activities that find out pupils' preconceptions;
- to have activities that stimulate pupils to think and discuss the topic;
- to let pupils apply newly learnt ideas in new contexts.

The following describes examples of the content for each of the above criteria.

In the topic "heat", the resource pack (Appendix E; Cheng, 1999) started with an overview of the topic in the form of a table that listed out the sub-topic, the preconceptions of the children, major concepts to be developed and the related activities. The topic sequence for "heat" was in the order:

- heat and temperature;
- expansion and contraction;

- the transfer of heat.

This sequence was perceived by the researcher as a more logical development than those suggested in most of the textbooks. The primary science textbooks usually start with a discussion of expansion and contraction, while the measurement of temperature using the thermometer was subsumed to be a theme under expansion. There was usually no discussion about the concept of heat or heat production or if these were presented, they were also one of the sub-topics under the topic expansion and contraction.

Under each topic, the major concepts to be developed were also listed. For example, the topic heat and temperature included the following major concepts:

- The sun, burning and a number of electrical appliances that can produce heat.
- Our skin cannot tell the difference about hot and cold very accurately.
- We can make use of thermometers to measure temperature accurately.

A summary of children's preconceptions in relation to the key concepts to be covered and the suggested activities were presented in a table as an overview (Figure 7a).

More detailed information about children's preconceptions were included and these were taken from reference materials developed by Driver (1989) (Figure 7b).

Content	Prior Understandings	Key Concepts	Activities
Heat and Temperature	Feeling hotness from electrical appliances. Pupils need to know what temperature represents – the degree of hotness.	The sun, burning things and some electrical appliances can produce heat. Skin can tell hotness and coldness but it is not accurate.	What do you think will produce heat? What is meant by temperature?
	Experience of using a clinical thermometer. Have seen readings of temperature in weather reports.	We use a thermometer to measure the temperature accurately.	How do we measure the temperature? using a finger using a thermometer.
Expansion and Contraction	What is meant by expand or expansion? What does contract or contraction mean?	When temperature is high, things will expand. When temperature is low, things will contract.	What is meant by expansion? What is meant by contraction?
	The word expansion means getting bigger or longer. Contraction means getting smaller or shorter.	Thermometers are made based on this idea of contraction and expansion. Other applications of this idea is found in building roads, pedestrian cross-overs and railways.	Applying the idea of expansion and contraction.
The transfer of heat	Knowledge of what are metals and non-metals.	Heat is transferred from one end of the object to another.	The transfer of heat from one end of the metal rod to another.
	Experience that metals "feel" hotter compared with non-metals at high temperatures.	Metal is a good conductor of heat and other materials like plastics are poor conductors of heat.	The transfer of heat in rods made of glass, plastic, wood and metal.
		Household utensils are designed based on this idea of good and poor conductors.	Applying the idea of good and poor conductors of heat.

Figure 7a Summary table of the key concepts, prior understandings and activities in the topic heat

Pupils may have the following preconceptions:

1. Pupils may think that "heat" is a substance and "cold" is another, they may enter or leave materials.
2. Pupils may think that hot is the opposite of cold and do not have a concept that they are on a continuum.
3. In explaining why metals feel to be cooler than plastics, they may explain this as:
    - Metals are easier to allow heat to enter or go out.
    - Metals may absorb cold.
    - Metals are cooler than plastics.
    - Heat cannot pass through the surface of metals.
    - Metals are harder.

Figure 7b Example of summary of children's preconceptions included in the resource pack

There were also points to note for the teacher like the distinction between some of the terms, for example, temperature, heat and heating, internal energy (Figure 7c).

Temperature

This represents how much energy this object may gain or loose. For two objects, which have the same volume, the one with a higher temperature has more energy. Energy will flow from the object at a higher temperature to one with a lower temperature.

Heat and heating

Heating is a process.

The internal energy of an object is different from heat. In gas, the internal energy may increase by an increase in pressure, but the process does not involve heating, though the temperature will increase after the increase in pressure.

Internal energy

This includes the potential energy and the kinetic energy of the material.

Figure 7c Sample notes for teacher

A diagram that shows how pupils' concepts might change or develop was also included for each sub-topic. (Figure 7d)

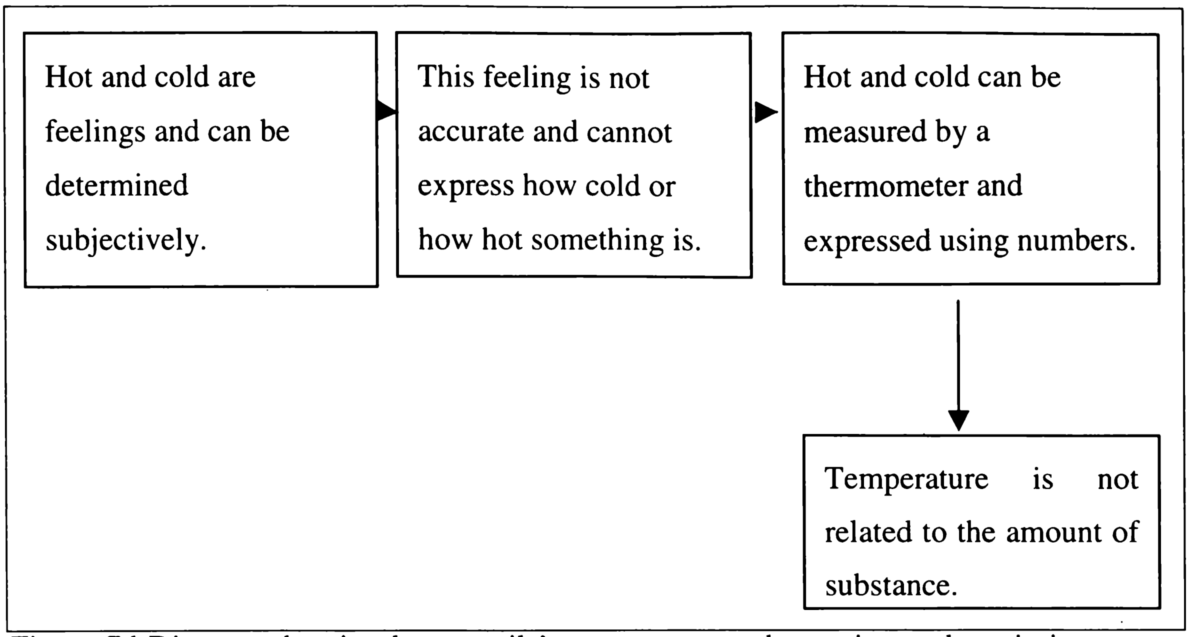


Figure 7d Diagram showing how pupils' concepts may change in a sub-topic in "heat"

At the beginning of each topic, there were suggested activities that aimed to check pupils' preconceptions or elicit their prior ideas about the topic. For example, in the resource pack "the body", the first activity was to ask pupils to gather in groups, draw a body outline on a large piece of paper, put in the outlines of the organs that they think are present inside the body and to write down five questions concerning the topic (Figure 7e). In the sub-topic on lungs, the pupils were asked to discuss in groups whether they had seen pig's lungs in the market, what they look like and why they are that colour.

The body

Name : __________

Class : __________

Date : __________

Questions :

1. __________

2. __________

3. __________

4. __________

5. __________

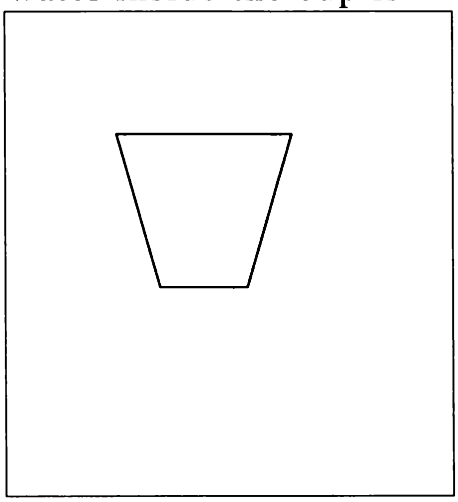
Figure 7e A worksheet for pupils to write down their questions

The discussion questions in the worksheets and the activities that helped to stimulate pupils' thinking complemented each other in engaging pupils in thinking. For example, in one of the activities that showed how the kidneys function, the activity was to use a funnel and filter paper to filter out the chalk powder suspension with red ink. The worksheet included questions that asked the pupils to think about what the red ink and the chalk powder represented and how the experiment related to the functions of the kidneys (Figure 7f).

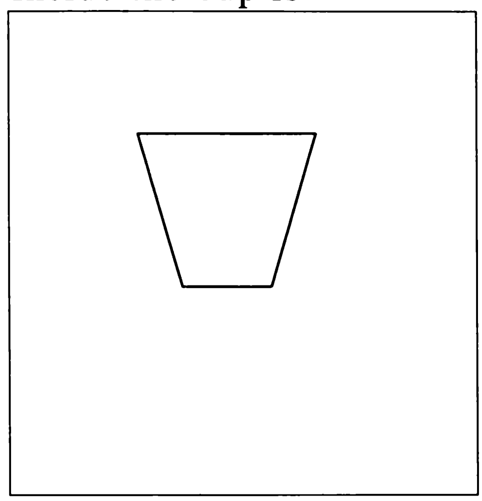
The function of the kidneys

Name : ____________
Class : ____________
Date : ____________

Before filtering, the water inside the cup is :



After filtering, the water inside the cup is :



In the activity : 1. Water is ________________

2. Chalk powder is ______________

3. The filter paper is ______________

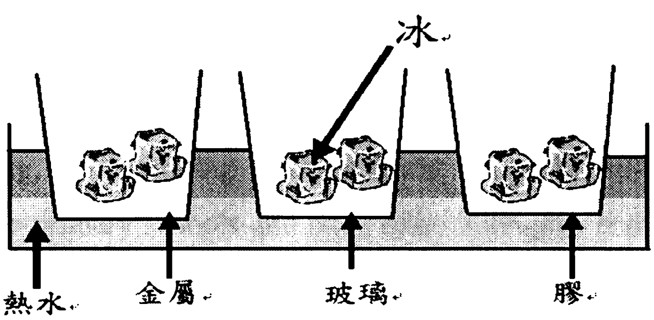
What do you think is the function of the kidneys?

Figure 7f Worksheet on a practical activity showing the filtering function of the kidneys

In other activities, the discussion questions were included in the overhead transparencies for the teachers such that the teacher could apply these in the discussions after a certain topic. For example, in the discussion about the functions of the kidneys, the overhead transparency included a question inviting the pupils to think about how the kidney functions and to represent it in an analogy.

The content of the resource pack not only included the topics within the scope of the textbooks but also extension questions for pupils to apply the newly learnt ideas. The applications are regarded as one of the important teaching activities based on a constructivist view of learning. For example, one of the extension questions included a question asking the pupils to predict the order of the ice melting in three cups each made of a different material, namely, foam, metal and glass (Figure 7g). After this, the pupils were asked to give explanations for their choices. The materials (three types of cups) were also included in the resource pack so the teachers could conduct the activity for the pupils to check out their ideas.

Ice



Hot water Metal Glass Plastic

Figure 7g Extension question in the transparency asking pupils to predict the order of ice melting in the three cups

7.6.2 Support for teaching science as a beginning teacher

The support for the beginning teachers mainly addressed three concerns that they raised in the interviews: the concern for the science background knowledge, the lack of time in lesson preparation and the lack of resources in the schools. In helping the beginning teachers with the science background knowledge, the resource pack included notes for teachers that explained the academic content knowledge. For example, in the topic on the heart, there were notes that described how to keep our heart healthy. This information is normally not included in the primary textbooks. Moreover, the overhead transparencies also presented the main concepts of the topics so that the teachers had an outline in their minds as they teach. To address the latter two concerns, the resource packs also included the materials for the activities such as the funnels, filter papers, large drawing papers, felt pens etc. In addition, the worksheets were presented in a form that was ready to be copied and used by the primary pupils. The worksheets therefore were in large font size and with spaces for pupils to write their answers.

7.6.3 The social aspects of support

The resource packs on the topic heat were given to the beginning teachers after they attended an introductory workshop. In the workshop, the beginning teachers shared with each other thoughts about their teaching in the past few months, their teaching schedule in the schools and their concerns about science teaching. The researcher made use of the opportunity to introduce to them the contents, the design and the aim of the resource pack. The beginning teachers also had an opportunity to try out each of the activities suggested in the resource pack. From the sharing, the beginning teachers learnt about the different pace of teaching among the primary schools and were more willing to implement the activities as they had successful experiences of trying them out in the workshop.

Another social aspect of support involved the interaction between the researcher and the beginning teachers. The beginning teachers were invited to phone up the researcher in cases of uncertainty. Moreover, the researcher made phone calls to the beginning teachers during their implementation to talk to them and to help them to solve any problem that came up during their teaching. During the school visits, the researcher also made use of the opportunity to explain to the beginning teachers about the use of the resource pack and the science content knowledge.

7.6.4 Stimulating beginning teachers to reflect on teaching

During the time period in which the beginning teachers implemented the resource pack, the beginning teachers were invited to reflect on their teaching using journals. Seven questions were included to help the beginning teachers to reflect on their teaching:

- How was the resource pack implemented?
- What was the activity and what was the pupils' response?
- What were the teachers' responses to the pupils' reactions and questions?
- Do you think the activity can stimulate the pupils to think?
- Was the lesson successful? What was the reason?
- If you teach this lesson again, what will you do?
- What support do you need?

Copies of the journals were mailed to the researcher. All the five beginning teachers responded in the journals. The contents of some of the journals were discussed during the interviews as the researcher visited the schools.

7.7 Summary

This chapter describes what science teaching was like as the beginning teachers started their first term of teaching. Their views of science learning, lesson preparation, perceived influences and confidence in teaching science were described. Based on their needs, a resource pack was designed to support their science teaching.

The beginning teachers viewed science learning as contextual and felt that science learning should be related to the pupils' daily life experiences. Compared with the previous phase after the teaching practice, the importance of learning science knowledge seemed to be lowered. The beginning teachers also found learning science to have a relatively lower level of importance when compared with the three main subjects in primary school in which the assessment results contribute to the entry to the secondary level. Preparing for science lessons mainly involved reading up the textbook and looking for teaching resources in the school. Two of the beginning teachers attempted group practical activities in the lessons and another considered the sequence of the topics with reference to the development of the concept. The beginning teachers also found discussions with other teachers in the school helpful in their preparation.

In most of the science lessons, there were mainly teacher questions and pupils answers, a mode that the beginning teachers described as whole class discussion. Two of the beginning teachers tried to engage pupils in thinking in their lessons. The more successful lessons reported by the beginning teachers in their journals were those in which they had considered pupils' preconceptions, clarified pupils' concepts, and in which the pupils participated actively or had more questions to raise. Though these lessons were not representative of most of the lessons, these reflected the beginning teachers' view of science teaching. They held a view that values pupil interaction, participation, engagement in thinking and taking into account pupils' preconceptions in their teaching.

In explaining why the beginning teachers did not always practice the successful lessons as described in the journals, the influence of the school context was found to be important. The perceived influences included limited time and resources, difficulties in classroom management and the tight teaching schedule. The more important influences came from other teachers in the school including the way they prepared lessons and the value they placed on pupils' achievement in examinations or tests.

The schools did not offer formal support for the beginning teachers, though the novices found the sharing with more experienced teachers helpful. In the face of the difficulties, some of the beginning teachers conformed to the school culture and put an emphasis on memorization and drilling. Others tried to keep up their beliefs, and encouraged the pupils to think in the lessons. The beginning teachers preferred to have support in terms of provision of resources and reference materials as well as social or collegial support.

Based on the needs of the beginning teachers, two resource packs that aimed to support their science teaching based on a constructivist view of learning were introduced. The packs were designed based on a number of criteria such as, helping the teachers to consider the topic sequence with helping pupils' conceptual development in mind, stimulating pupils to think, and applying new ideas. Moreover, the introduction of the resource packs was coupled with social support and opportunities for the beginning teachers to reflect on their teaching.

Learning to teach is a sociocultural process, as the findings suggest that the influence from other teachers, the tight teaching schedule, the heavy workload, and limited resources in the school are significant for the beginning teachers. These influences may be taken as sociocultural factors that shape learning and teaching in the classroom and the school. Moreover, the request for support from other teachers or opportunities for sharing teaching experiences can be taken as chances for interactions which in turn are mediated actions that help individuals to learn about the culture of teaching science. The support provided by the researcher in the form of the resource packs is a mediational means while the social supports are mediated actions. These carry the intention of the researcher in helping the beginning teachers to teach science with a constructivist view of learning.

Chapter 8

Beginning teachers using the resource packs

8.1 Introduction

This chapter describes the experiences of the beginning teachers in using the resource packs. Among the five beginning teachers, one (teacher B) used the resource pack on the topic "the body" at primary four and the other four (teachers I, L, E and D) used the resource pack on the topic "heat" at primary two. The findings reported in this chapter included those from the interviews, lesson observations and the journals of the beginning teachers.

The first part of the chapter reports on how the beginning teachers implemented the resource pack in terms of which were the contents that they picked to use, their criteria for choosing the contents, their comments about the resource pack and if or how other teachers in the schools were involved in the implementation. The second part of the chapter discusses what the teaching was like during the implementation. The discussion includes: teaching strategies that the beginning teachers employed, the ways that the beginning teachers mediated conceptual change among the pupils, and the influences on their teaching. The third part of the chapter considers the learning of the pupils in terms of the learning conditions and the learning outcomes in the science lessons during the implementation. The fourth part of the chapter looks into the perceived influences on the beginning teachers after the implementation of the resource packs. The beginning teachers' predicted future directions in teaching and their confidence in science teaching are included.

8.2 The implementation of the resource pack

This section describes how the beginning teachers implemented the resource pack. The way that they implemented the resource packs provided information on their views of science teaching and learning, possible influences from the school context on their science teaching and their influence on the school context as a result of their endeavor. Moreover, the beginning teachers' comments about the resource pack are also discussed. In the interviews, in order to collect the views of the beginning teachers, they were asked to answer the following questions:

- Can you describe how you have used the resource pack?
- Did you discuss with your colleagues or peers the use of the materials in the resource pack? What were the discussions about?
- Do you have any suggestions on how to improve the resource pack or support the teaching of beginning teachers?

8.2.1 How the resource packs were used

Though the beginning teachers (I, L, E and D) were given the same set of materials that supported their teaching on the topic heat, they had different ways of implementing it. As perceived by the beginning teachers, these were ways that were feasible and provided the greatest benefit in their situation. The suggested sequence of the topic was as follows:

- The sources of heat production
- Hotness and temperature
- Weather and temperature
- Expansion of solids
- Expansion of liquids
- Expansion of gas
- Contraction
- Transfer of heat
- Application of heat transfer
- Insulation

Table 8a represents the topic sequence adopted by each of the four teachers. Among the four teachers, two teachers I and E closely followed the sequence of topics suggested in the resource pack. The other two teachers (L and D) tried to adhere to the content in the textbook in which the topics may not be developed or designed according to conceptual development or even in a logical sequence. Adhering to the topic sequence suggested in the textbook may mean that these teachers are less ready or confident to change their current practice or make their teaching too different from other teachers in the school. This also suggests that they are ignoring the logical sequence of concept development, which is based on a constructivist view of learning.

Table 8a How the beginning teachers made use of the materials in the resource pack on "heat"

Sequence in the resource pack	Teacher I	Teacher L	Teacher E	Teacher D
Sources of heat production	Used this part as a supplement to the textbook as this is not covered or discussed in the text.	Not discussed	Followed sequence of topic as suggested in resource pack.	1st topic Discussed under the topic on expansion and contraction
Hotness and temperature		1st lesson starts with measuring temperature as suggested in the textbook		4th topic
Weather and temperature		Not discussed		Not discussed
Expansion of solid	Order covered as suggested in the resource pack	2nd lesson		2nd topic
Expansion of liquid		1st topic Introduced together with measuring temperature so as to demonstrate how thermometer works		
Expansion of gas		2nd topic		
Contraction		Discussion of examples		3rd topic
Transfer of heat		3rd topic		5th topic
Application of heat transfer		3rd topic	Discussion	Discussion based on textbook
Insulation	Not discussed	Not discussed	Discussion about home-made thermos-flask and the melting of ice in three cups of different materials	Not discussed

For teacher L, measuring the temperature with a thermometer was discussed together with the expansion of liquid. The sources of heat production were not discussed, as this was not covered in the textbook. The second topic was on the expansion of solid and gas while the whole topic on heat ended with a discussion about the transfer of heat. The teaching sequence actually reflected how the topic was treated in the textbook. There were two chapters in the textbook, one on expansion and the other on the transfer of heat. All the concepts were grouped under these two headings without consideration for pupils' preconceptions or the conceptual development.

For teacher D, the first topic on sources of heat production was taken from the chapter about expansion of solids, liquids and gases in the textbook. She was aware that the sources of heat production should be discussed prior to other topics because of the suggested sequence in the resource pack and thus teased out this part from the middle of the first chapter in the textbook. The third topic contraction was also coming from the same chapter in the textbook on expansion. To align with the sequence in the resource pack, teacher D put this part after the discussion about expansion. The fourth topic on hotness and temperature matched with the second chapter in the textbook about temperature measurement, while the fifth topic matched the third chapter in the textbook about transfer of heat. The sequence thus followed closely that of the three chapters in the textbook. As teacher D was aware of the suggested sequence in the resource pack, she adjusted the topic sequence with a consideration for pupils' conceptual development. At the same time, the topic sequence did not deviate too far from that in the textbook after the adjustment.

As for the application of the teaching activities and teaching ideas suggested in the resource pack, teachers I, L and E adopted most of those included. Teacher D performed only three of the activities suggested in the resource pack though she maintained that the worksheets helped her to raise questions for discussions during the lessons. Among the four teachers, Teacher E had the most thorough treatment of the topic as he did not stop teaching at the application of heat transfer but continued to pursue discussions about insulation and compared the rate of ice melting in cups made of three different materials with the pupils. The last part about insulation was taken as an application of the newly learnt ideas on heat transfer. This topic was not included in most of the textbooks.

The other teacher (teacher B) who implemented another resource pack on the topic "the body" followed closely the topic sequence as suggested in the resource pack, except that the first activity which was an overview about the organs in the body was used as a concluding exercise for the whole topic. By doing so, the topic sequence matched exactly that of the textbook.

Among the two resource packs, the topic sequence for the package on the topic "heat" differed more from the textbook than the one on "the body". As the arrangement in the textbooks was more arbitrary than sequential, the sequence of introducing the concepts influenced the way the pupils build up their concepts about heat. The way the teachers attempted to match the sequence in the resource pack with that in the textbook suggested that they were keen to follow the textbook chapters in their teaching. While having a background of teaching science based on a constructivist view of learning, these beginning teachers tried to achieve a compromise between a sequence that helps pupils' conceptual development and that in the textbook. The decision to follow the topic sequence in the textbook or that of the resource pack can be interpreted as a result of the tension between the school culture of teaching following the textbook and the culture of teaching science based on a constructivist view of learning.

The beginning teachers related in the interviews how they arrived at the choice for the topic sequence. Making a choice of the sequence of the topics or the teaching content represents how strongly the teachers held the constructivist view of learning or how influential the teaching culture in the school was. Four of the teachers suggested making a comparison between the suggestions in the resource pack and the content in the textbook. Among them, three of them (E, B and I) based their teaching more on the suggestions in the resource pack. Two of the beginning teachers related how they tried to match the contents:

> The content in the resource book can match with the main points in the textbook. (Ij2) (See Chapter 3, section 3.4.2 for a description of the coding)

> I try to figure out how pupils will think about the topic, what is the sequence that they should have. I identify the sequence in this way. The textbook and the resource pack may be different on this. One of them may not be very adequate...The resource pack may be talking about the same thing but in a more direct way. (Ebi3)

Teacher L has chosen to match the contents while using the textbook as a base. Teacher D did not report on comparing the contents. Her treatment of the topics suggested that she had more concern in covering what was laid down in the textbook.

Teachers I, B and E have positive views on the design of the worksheets as they have distributed them to the pupils, used them together with the practical activities and appreciated the simplicity that suits the pupils' ability:

> The first part is not covered in the textbook and I find that the inclusion of these worksheets is an advantage. For the other activities, they are available in the textbook and so I did not copy it out for them. (Ibi3)

> They are just simple ones, asking them to circle answers there is not too much writing, they are workable. (Ebi2)

> I distribute the worksheets to the pupils before the lesson and they then cut it out at home before the lesson. During the lesson, they then stick the parts together. It was very useful...Most of the pupils can generally achieve the aim and requirements of this activity. (Bbi2)

Using the worksheets to guide their discussions with pupils was mentioned by two of the beginning teachers:

> I use the worksheets to guide the discussions; these can guide my teaching and are quite useful...I read and take the questions for discussion and make use of the content. (Dbi3)

> If there is enough time, I use them (the worksheets). I put it on the overhead projector and discuss the questions with the pupils. (Ebi2)

Teachers D and I skipped the simple ones as they found that it took too much effort to copy the worksheets and if the content was simple, they thought that the task was not worthwhile.

> I skip the worksheets that ask pupils to colour the parts producing heat... It is good but there may be too much content for the pupils and there is not enough time to cover it all. (Dbi2)

> Some of the worksheets can be combined together so that we do not need to copy such a lot of worksheets. (Ibi3)

The resource pack was found by teacher E to have helped him to consider pupils' preconceptions and he re-arranged the sequence of topics that best facilitated the development of concepts:

> The textbook talks about what are the things that produce heat, then the thermometer and go back to the feeling on temperature using fingers. I think there is a problem with this, feeling the temperature after introducing the thermometer does not seem to be very appropriate. It is better to reverse this, as it is not accurate using the fingers, using the thermometer is much better. (Ebi2)

> I try to find out what are the topics that the pupils have learnt previously. In this lesson, distinguishing the metal and non-metal is one of the pre-requisites. Actually, they have learnt this in primary one as they learnt about magnets. They can tell these and this is a revision. I will consider what they have learnt and what are the things that they will often meet in their daily life experience...I hope that the pupils can take what I am teaching. This is active. That is to consider how to teach so that the pupils can learn better. (Ebi3)

The first quotation illustrates how teacher E considered the logical sequence of the sub-topics and rearranged the topics to be different from those in the textbook. The second one describes how he considered what pupils knew before the lessons and viewed teaching as getting pupils to learn better.

The resource pack was used in a different way by teacher D. Instead of stimulating pupils to think, she emphasized repeating the explanation to the pupils to make them learn and to use the worksheets with an aim of helping pupils to revise the contents instead of stimulating their thinking in class. The main task for the teacher was seen as explaining and for the pupils it was remembering and revising:

> I found that this is a very long topic and there are a lot of things to explain to the pupils. I may have to repeat my explanation again before they can fully understand. Even the pictures in the book take some time to explain. It is quite difficult for the pupils at primary 2 level. (Dbi3)

> I would prefer to print the one (worksheet) with different materials and which are the ones that transfer heat e.g. there is a rubber band. This helps them to remember, for example, they can mark down the ones that are good conductors of heat on the worksheet and this helps them to revise. (Dbi3)

The contrast between teacher E and teacher D in their views of teaching is apparent as one (E) referred to teaching strategies that were made based on a constructivist view of learning while the other (D) held a didactic view of teaching. How the teachers considered the topic sequence and their description of implementing the resource pack reflected their beliefs in teaching science. The way they attained a compromise between the requirements of the school and the expectations of the parents in teaching the text reflected their own beliefs of science teaching. Among the five teachers, teacher E held more strongly the constructivist view of learning and teacher D taught using more teacher-talk in the lessons while being aware of the importance of helping pupils' conceptual development. The others teacher B, I and L were trying to accommodate the requirements of the school while being aware of the implications of engaging pupils in thinking which is consistent with a constructivist view of learning in science teaching.

8.2.2 Criteria for the choice of implementation

During the course of selecting the content in the resource pack for implementation, the beginning teachers adopted different criteria as they make their choice. These criteria are grouped into four areas: the content of the teaching, the confidence to teach, considerations of the constructivist view of teaching, and practical concerns in the school context. These criteria provide information on the beliefs about science teaching held by the student-teachers and the sociocultural factors at work in the school context.

The concern about the content of teaching was shown as two beginning teachers (B and E) related whether the worksheets matched the teaching objectives, helped the pupils to learn more and made sure that the class did not learn less content than other classes:

> I will also have to note if there are things that I have taught but were not covered by other teachers. I have to avoid teaching topics that are not covered by other classes, or that it turns out there are some topics that only my class has learnt. I will compare the pack and the books, then choose the activities...I have to cover all the things as not all the classes are using the resource pack. My class may know something not learnt by other classes, but if there are things that my class does not know while all the other classes know, then there is a problem. (Will this happen?) I don't think there is one at the moment. However, there is more information in the resource pack than in the books. The former situation is more likely. (Ebi2)

> See if the activity is appropriate in terms of the aims of teaching. For example, the worksheets are appropriate to the topics that I am teaching, secondly, see if the worksheet is effective in helping pupils to learn. (How would you determine the effectiveness?) The main concern is on the knowledge learnt by the pupils, if they can absorb more knowledge, it would be useful. (Bbi3)

The second area was on the confidence to implement the resource packs. Another beginning teacher (I) related how the trying out of the practical activities in the workshop was important:

> The practical activities in the resource pack are feasible, as I have tried them in the laboratory, so I decided to apply them in my teaching. (Ibi3)

Apart from considering the feasibility of the activities, two beginning teachers (L and E) tried to relate the purpose of the activity and considered the alternatives, for example:

> I think there is a practical activity that was more clearly represented in the resource pack than in the textbook. The effect is also better. The one on the feeling of the skin on hot and cold water. The resource pack has suggested using three cups of water but the textbook suggested two. The experiment was conducted in a different way. I think that the one in the resource pack will make it easier for the pupils to understand. (Ebi3)

This quotation shows the third area of concern which arises from a constructivist view of learning as the teacher was thinking about how to help pupils to understand the concept.

Teacher D reflected more practical concerns about the choice of the materials, as she related her considerations for how other teachers regarded her teaching, the classroom management and the time for teaching the topic:

> I would not do that and am afraid that it is dangerous. I am afraid that someone may pass by and see this. I am not too comfortable having fire (a candle) in a practical activity. (Dbi3)
>
> Those that cannot be applied are due to very practical reasons, not because the design is not good. It may be due to time constraints. I may just want to prevent too much chaos in class and give up the idea...There may be some that are repeating each other e.g. the two practical activities on heat transfer, I am thinking that the two are overlapping. Maybe the first one is on heat transfer along a metal rod while the other one is on the conduction of heat in different materials. I am thinking which one is better, maybe the pupils have already learnt that the one near the fire is hotter and so that one is skipped...Time is very important and I have to catch up with the teaching schedule. (Dbi3)

Though she was aware of how the practical activities were arranged in order to help pupils' conceptual change, she regarded them as repeating practical activities. With the purpose of catching up the teaching schedule, she skipped one of them.

The beginning teachers had set different priorities in their teaching. Teachers B and E were more concerned about the content that was covered as compared to other classes. At the same time, teachers E and L were aware of the purpose of doing the activities and tried to consider alternatives in their teaching. Teacher I regarded the trying out of the practical activities as an important influence on her confidence in implementing the materials. Teacher D placed her priorities with the pace of teaching, the classroom management and how others may view her teaching.

Having described the criteria adopted by the beginning teachers, the next part in this section looks into the perceived influences on the implementation of the resource pack. These factors also contribute to how the materials were implemented. Five groups of influences were evident from the findings: resource management, the views of other teachers, classroom and time management, the pupils' ability, and the teachers' background knowledge in science.

Three of the beginning teachers (teacher I, L and D) related how the limited resources in the school influenced their implementation of the materials in the resource pack:

> The pupils were enthusiastic in the practical activities and were more attentive; however, they were disappointed, as there were not sufficient materials to go around. (Ij2)
>
> The school may find us printing too many worksheets for the pupils. As there is no school name on the worksheets, they may suspect the teachers. (Ibi3)
>
> It is hard to teach the topic without the thermometer. (How about the feelings of hot and cold?) For that they can manage. I find it hard to show the OHTs (overhead transparencies) and there are no machines around and it takes quite some time to set up the projector. There isn't a screen in the classroom. (Lbi2)

Moreover, the procedure required from the school in copying worksheets and the workload of the teacher did have some effect on how the beginning teachers chose to employ the suggestions in the resource pack. For example:

> It is very troublesome to copy the worksheets for the pupils. The school may find that there is already a lot of work and do not grant permission for the printing of the worksheets...They (the school) would look at the purpose of the worksheets. They may think that it is just asking pupils to draw their observations and so do not grant permission for printing. (Lbi2)
>
> Just as in the next lesson, I had another lesson before that and I could not get things prepared beforehand, it was quite chaotic. I had to get the things together in between the two lessons. That is some arrangement problem. However, this has to be overcome, otherwise not a single experiment is possible in the lessons. There are problems in arranging practical activities. (Dbi3)

These difficulties influenced the beginning teachers' science teaching in terms of their choice of activities and practical activities. Moreover, the limited time available for teaching was mentioned by four of the beginning teachers (B, I, E and D) while difficulties in classroom management were mentioned by two of them (I and L). For example:

> There is only 20 minutes in this lesson. Everything is in a rush and it starts to go chaotic. (How do you feel about the performance of the pupils? Do they behave in the same way normally?) I think it is a matter of time, they are pushed to take out their books as soon as possible and to start the activity right away. (Bbi2)

> (Are there other influencing factors?) Time and the preparation work. The content is the most important, then comes time and preparation and pupils' thinking is the third. (Why do you come up with this?) At least, I have to know what I am going to teach. If there is no time, nothing is possible. All are actually important. (Ebi3)
>
> It is good but that may be too much content for the pupils and there is not enough time to cover it all. (Dbi2)
>
> I will use it as a reference and it depends on the time available. (Dbi3)
>
> Sometimes I would also use GS (General Studies) lessons to teach mathematics, as mathematics is more difficult. Time and classroom management then become the limiting factors and some of the activities cannot be conducted. (Lbi2)

The limited time available for teaching influenced the quality of the teaching in the classroom as teacher B reflected how the pupils had to move into the activities right after the lesson was started. Teacher E compared the importance of the considerations in planning for lessons and found that time was a limiting factor. Teacher D shared a similar concern in her preparation. The beginning teachers had different views and situations about their classroom management. Teacher I related that the class was manageable when the pupils were occupied in the group practical activities while the demonstrations created more chaos:

> The group activity has made the classroom manageable. The experiment has helped pupils to make accurate observations. (Ij2)
>
> The pupils were quite noisy and chaotic. If they sit down, they should be able to see the results clearly but they just shouted that they couldn't see. It was a bit chaotic in terms of classroom management but I can finish my plan with sufficient time. (Ibi3)

On the suggestion of conducting group activities, Teacher L described that it was hard to manage the class as follows:

> It is hard to manage the class if the pupils get too excited. (Lbi2)
>
> The pupils are very active and it is very chaotic if the practical activities are conducted in groups. There is much limitation and it would be better and more controllable if the practical activities are demonstrated. (Lbi2)

With this suggestion, demonstrated practical investigations were preferred over group activities to reduce classroom management problems. Teacher L was also concerned about the pupils' ability:

> There are more pupils at the medium and only a few at the extremes. The pupils have more diverse views on the experiment with the table tennis ball and is more unified on the one using the water bottle. (Lbi2)

Teacher B had some difficulty with understanding the activities or materials in the resource pack and in answering pupils' questions:

> It depends on my own understanding of the activity or the materials. (Bbi3)
>
> This was not a successful lesson, though pupils have asked questions about the content, I was not able to answer the questions. (Bj2)

In summary, the major influences included concerns about knowledge, confidence to teach, their view of science teaching, pupils' ability, classroom management, time management, resources, time for teaching, and what other teachers might think about their teaching. This is congruent with a sociocultural view, which regards these influences as arising from the school culture and the speech genre of the context. Though other teachers did not explicitly say what they think science teaching should be like, their attitudes about practical activities, the strong adherence to the textbook, and the lack of use of resources communicated to the beginning teachers what teaching science was perceived to be like generally, and that this practice was commonly accepted by the teachers. Despite this, the beginning teachers' views of teaching science and their personal confidence in science teaching were also influential which may add to or diminish the influence from the school context. The next section describes how other teachers in the schools were influenced by the beginning teachers implementing the resource packs.

8.2.3 Influence on other teachers in the school

From a sociocultural view of learning, the individual may also influence the social context and re-define cultural practices during the learning process. It is therefore interesting to find out if the resource packs had an influence on the teaching of other teachers in the school. Moreover, the supportiveness of other teachers may influence how far the beginning teachers were ready to teach science with a constructivist view of learning. In the interviews, the beginning teachers were asked to describe if they discussed the use of the resource pack with other teachers in the school, and what the discussions were like. Though the resource pack was introduced to the participants in the study, one of the participants shared the materials with all the teachers in the school. There were discussions about alternative ways of conducting the activities and the teachers have found the suggestions in the package to work better. Two beginning teachers had some successful experiences in sharing the materials, as Teacher L shared one of the activities with a colleague and teacher B shared the resource pack with a teacher sitting next to him in the staff room. However, these teachers only implemented one of the activities in the resource pack:

> We discussed this topic and found that this experiment can be performed. And she found the activity using the water bottle to be suitable and has taken away one of them to try. She has used cold water and put it in warm water but finds that it takes much longer if we use our hands to warm it up. (Besides this activity, did you discuss other things in the resource pack with your colleagues?) Yes, but they say that it is not necessary. She just takes the water bottle... We were talking about this and then I offered that there is such an activity. It is not done on purpose but just that we had been talking about this. (Lbi2)

> I asked the teacher teaching the neighbouring class to try out using the materials. That class has a more serious discipline problem than my class. It was more chaotic to both control the discipline and to conduct the activities. He found it very chaotic. (Does it help to have a colleague to discuss with you or implement the pack together?) I have someone to talk to about the implementation details. We may think out different implementation methods and not just follow the instructions. (Bbi2)

The discussion with another colleague about the teaching activities led to new ideas and alternatives for the implementation. The sharing of teaching ideas and materials among teachers in the school was uncommon as two other beginning teachers I and D saw little possibility of sharing the materials with other teachers. Teacher D worried about conducting practical activities with a candle in the classroom and was afraid of what other teachers passing by may think of her teaching. She did not print out the worksheets for her pupils, as the school was not supportive of having extra materials given by individual teachers. This may also explain why she implemented the resource pack to the minimal extent as compared with other teachers in the study. Teacher I described how she had limited knowledge about what was going on in the classroom next door as she said:

> Another teacher asked for a lighter but I do not know which experiment the teacher demonstrated. This one that involves using candles was only performed by me. Another teacher has talked to me about the materials but found it too troublesome and gave up. Their aim was to do something convenient. They seldom do practical activities during the lessons. There are altogether four teachers. (Did you talk to the other three teachers?) One day, one of the teachers asked for the lighter, another teacher suggested that the lighter was used by the teacher of class A. The teacher in class C said that she would not be doing any. (How do the teachers decide which experiment they are going to perform?) They will mostly follow the textbook. (Do they discuss the possibilities?) If I don't have the resource pack, I will also follow the textbook. (There is not too much discussion with other teachers?) Not much. There is not enough time. We are doing things separately. It is hard to find time to gather the four of us together. (Ibi3)

Though she attempted to introduce the resource pack to another teacher, it was not taken as this may mean extra preparation for the lessons. As teacher I reflected, science teaching was often bounded by the textbook and there was little sharing among the teachers about their teaching. A different situation came up with teacher E who was the deputy GS (General Studies) co-orindator in the school. He shared the resource pack with seven other teachers (in the morning and afternoon sessions of the school) teaching the same topic, and gave them the materials for the activities. There were also discussions about how to improve the activities and if there were alternatives in conducting the activities:

> Another colleague used the conical flask and the effect (the balloon getting bigger) was seen. But I am afraid that the glass may break. (Ebi2)
>
> Most of the discussions were about how to conduct the practical activities, how to solve technical problems, if there were any tricks to be aware of. The teachers in the morning session found the

> experiment with the butter successful; others in the afternoon session could not make it. They tried a number of times. They then note the tricks and all of them follow the tricks. (What is so special about it?) The clips fall down very easily and the sequence is not correct as today. Some of them may have the butter drops too far away. This has taken up a lot of time. They do not stick well if they are too small.... They have even thought of pulling the arms of the clips a bit further apart. (Did they mention how the pupils behaved in the lessons?) They found the pupils happier in the lessons. They were more involved than just listening to the teacher talk. (Ebi3)

From this description, the science lessons for this topic in the school were more enjoyable and the teachers had helped each other in trying to make the activities successful in the lessons. The exchange of the teaching experiences was helpful. While the other teachers shared their experience and discussed about science teaching, teacher E reflected that it was an experience that was beneficial to both the pupils' learning and his own development:

> I feel that they are happy to use them. There may only be a difference in the extent of application. (How do you feel about this as you provided the materials?) If they are happy to use them, I do feel happy. I also hope that they will provide their opinions so that they can be improved next time we use them. These will be good for the pupils and for me. (Do you find their opinions helpful and that the practical activities can be improved?) Yes. (Ebi3)

Though the overall impact was good, teacher E related some worries with the situation:

> (You have been quite influential in this process. How do you feel about this?) If the colleagues do not mind, I think this is quite good. I am afraid that some may think that it is not so good if the activities are run in your class but not mine. If there is such a problem, then it is not so good. As everybody is sharing their experience about using these and we are all trying to do it, they do not compare or feel any pressure with it, and then it is an advantage. (Do you think that such a problem exists?) I do not see this superficially, but I do not know if deep feelings are concerned. (Ebi3)

In this quotation, he was worried about the feelings of other teachers. Other worries include the concern for classroom management and the expectation of the school principal:

> I feel that the most important thing is how the school thinks. Everyone has a different view about how quiet a class should be.

> (Do you mean the school principal?) You may say so. They will expect the class to be quieter. But I do feel that they are noisy. (Ebi3)

From this, he was concerned about what the school principal thought about his classroom management skills. On the whole, this sharing of the resource pack was a successful experience for both the teachers in the school and teacher E. Despite the worries about his colleagues' feelings and classroom management, he described how long term changes about preparing for science lessons were possible based on this experience:

> We are not teaching the same level every year. It is good that colleagues can leave something behind for other teachers teaching the same level in the coming year. New teachers teaching the same topic in the next year will not need to start from nothing. This may influence my motivation to prepare something for other teachers, things that are placed in the school and are handy for other teachers. (Does this have any influence on your confidence?) These are helpful and I am more confident. The information has backed me up as I teach. The discussions between the teachers at the same level during lesson preparation are very helpful. (Ebi3)

As teaching science for other teachers in the school may mean lessons mainly based on textbooks, with little opportunities for sharing between teachers, teacher D was afraid to let other teachers know that she was doing a practical activity that involved using a candle and was using extra worksheets for the pupils. Teacher I described the lack of knowledge about how other teachers were teaching in their classroom and the isolation of the teacher's work.

The meaning of being a science teacher was different for teachers B, L and E. As a teacher in the school, the beginning teachers attempted to share their materials and experiences with other teachers. Teacher E shared the resource pack with seven other teachers in the school, and the other beginning teachers B and L were ready to share their materials with other teachers, though the influence was not significant. While these teachers (E, B and L) had tried to or succeeded to influence other teachers in their teaching, the social context and the interactions between teachers had an influence on the individual teachers. From the experience sharing by teacher E, he found that discussions with other teachers were helpful to his and other teachers' development, and the experience motivated him to support other teachers in a similar way in the future.

The findings also suggest that for the beginning teachers in the study, teaching science means to plan and prepare for lessons, to provide activities, making the lesson enjoyable as well as managing the classroom.

8.2.4 Beginning teachers' comments on the resource pack

Having described how the beginning teachers used the resource pack, their criteria for choosing the materials and how other teachers were influenced in the process, this section looks into in what ways the beginning teachers found the resource pack supportive. This may be seen as evaluation of the effectiveness of the on-going support provided by the researcher in an attempt to help the beginning teachers to teach science based on a constructivist view of learning.

In identifying the ways that the beginning teachers found the resource pack helpful, the beginning teachers were asked to describe their comments on the resource pack and to suggest ways of improvement. The comments from the teachers are categorized into four areas: the content to be taught, conducting activities to help pupils think, teaching with a constructivist view of learning, and the availability of resources. The resource pack was related to be a support for the beginning teachers in terms of the content to be taught. Three of the beginning teachers (teachers I, E and D) described how the suggestions and explanations were helpful:

> The explanation or notes for teachers are quite good. The content is adequate and there are explanations. (Ibi3)
>
> The preparation is better...There is information that I do not know or that is not covered in the textbook...The content, the activities, their preconceptions, having these I will note them as I teach. (Ebi2)

The activities were found to have stimulated the pupils to think as mentioned by teacher B in the journal:

> Pupils were able to think in the activity as they are doing the practical activities by themselves. The lesson is successful because:

- Pupils can prove what they cannot see in their daily life experience with the experiment;
- Pupils have hands-on experience themselves;
- A good learning atmosphere is cultivated. (Bj2)

Four of the beginning teachers (teachers E, D, B and I) were also aware of how the resource pack had made their teaching more congruent with a constructivist view of learning. Teacher E described how he found the information about pupils' preconceptions useful:

> Among the other contents in the resource pack, those that concern the building up of pupils' concepts are very good references. These can be compared with the textbook and I can decide which is more applicable. Each has their advantages. (Ebi3)

His concern about pupils' conceptual development was demonstrated as he reflected on one of his lessons:

> They should have known the two concepts. It is not accurate to use our fingers to measure the temperature, and we cannot tell how cold or how hot it is. The second thing is that, it is more accurate to measure the temperature with a thermometer. They should have known this. (Ebi2)

Though teacher D was not able to implement many of the activities in the resource pack, she was aware of how the concepts were presented:

> The resource pack has arranged the concepts from the easy to the more difficult ones; this is also true for the practical activities. I may try to think about this in other topics and start with something simple as in the first worksheet where you ask the pupils to identify the sources of heat production. (Dbi3)

Teacher B realized how pupils' understanding of the word "muscle" might influence their learning as he said:

> Yes, the most important is to see what they understand by the word muscle,...They have a concept that only those that we see on our feet and arms are muscles, those that are in the internal organs, lungs and heart are not. (Bbi2)

This may be taken as pupils' preconceptions about the topic. At the completion of the topic, he recognised the importance of helping pupils to link up what they have learnt:

> There are some relative positions (of the organs in the body) that they (the pupils) are not very clear about and do not have a concept that the organs may overlap each other. They think that the organs are all lined-up. They do not know that the heart is a bit covered by the lungs and think that the kidneys are below the intestines lower down the body. They know roughly the positions but the relative positions are not clear. (Do you think that knowing the relative positions is important?) Yes, they need to know this. (Bbi3)

In this quotation, linking up the concepts learnt was seen to be important. Another influence of the resource pack was suggested by teachers I and D who described how the pupils were reluctant to switch back to the previous form of teaching after the implementation lessons:

> The content is mostly based on the textbook. It is mostly the teacher telling and pupils, sharing their life experiences. The pupils are not as interested as in the previous lesson as they are used to having practical activities and activities in the other lessons. They should be very used to this type of teaching however, after all the practical activities and activities in the previous lessons, they are not as happy in this lesson. (Ij2)
>
> Stimulate pupils to think:
> (In a lesson, after the implementation of the resource pack was completed.) Not quite as the topic is not very attractive and there is no activity. (Dj2)

As the location of resources to support teaching was one of the problems of the beginning teachers, two of them (B and D) regarded the resource pack as helpful as it provided adequate resources for their science teaching:

> It may be hard to locate the right resources. (Without the resource pack) I may not be able to find all the right puzzles. I may not be able to find out the activities on the sense of pressure, etc. (Bbi3)
>
> The resource pack is very helpful; the availability of teaching aids is also a support. (Dbi3)

On the whole, the beginning teachers found that the resource pack supported their teaching in different ways. Teacher D was particularly concerned about being able to give pupils more examples or ways of proving certain concepts. She was also concerned about the availability of resources for teachers. Teachers B and E had shared concerns in teaching that are related to a constructivist view of learning. Their comments reflected the importance of considering pupils' preconceptions and conceptual development in facilitating learning. Moreover, Teachers I and D realized that at the end of the implementation, pupils were reluctant to switch back to their original modes of instruction, i.e. lessons predominated by teacher-talk. Teacher I appreciated more the support for the content to be taught and the information about conducting the activities.

8.2.5 Summary

This section has described how the resource packs were implemented, the intentions of the beginning teachers as they implemented the packs, the influences on other teachers as the packs were implemented, and the ways that the beginning teachers found the packs supportive.

The choice of implementation of the materials in the resource pack was made based on considerations between influences from the school context and concerns about science teaching based on a constructivist view of learning. The beginning teachers were facing a dilemma between following the textbook sequence and the sequence suggested based on the conceptual development of the resource pack. Two of the beginning teachers (teachers L and D) were more concerned about the content taught in the textbook and used the materials in the resource packs to supplement the textbook content. The concern for the teaching content was also shared by teachers B and E, though they maintained the topic sequence suggested in the resource packs. Other beginning teachers (E and L) had the intention of trying to consider alternatives in their science teaching and to improve on their practices or the activities they conduct in classes. Teacher I implemented the activities based on her confidence to conduct them successfully in class.

The beginning teachers related a number of contextual concerns. These included concerns about classroom management, time for teaching and available resources. Furthermore, other teachers in the school had an influence on their implementation while the implementation also had an influence on other teachers as well. Teacher D was particularly conscious of how other teachers looked at her teaching, and teacher E was successful in motivating other teachers in the school to implement, discuss and improve on the suggested activities in the resource packs.

On the whole, the beginning teachers found the support for the content knowledge, the suggestions for the activities and the resources provided applicable. Moreover, the support may strengthen the constructivist view of learning and help beginning teachers to realize the importance of considering pupils' preconceptions and conceptual development in the topics to facilitate pupils' learning. The next section looks into the teaching strategies employed by the beginning teachers in stimulating pupils to think, and how the lessons were conducted.

8.3 Teaching science with the support of the resource packs

This section reports on how the beginning teachers teach in their science lesson with the support of the resource pack. The data suggests how far the beginning teachers taught science with a constructivist view of learning as well as whether the support from the researcher facilitated their teaching. The first part provides a description of the teaching strategies employed by the beginning teachers generated from the interview findings. The second part is an overview of what the science lessons were like. The third part gives an account of the lessons observed and identifies ways in which the beginning teachers helped the pupils with conceptual change.

8.3.1 Teaching strategies that were employed

In the interviews, the beginning teaches were asked to describe the ways they employed to elicit pupils' preconceptions, how they helped pupils to apply the concepts, and ways that facilitated pupils to think. This part summarizes the teaching strategies reported by the beginning teachers. Two of the beginning teachers (B and E) suggested that they attempted to find out pupils' preconceptions and this happened usually at the commencement of the topic:

> I will do this in the first lesson. For example, with the thermometer, some of them should have seen this previously. I ask them how to read this and what is inside. (Ebi2)

The beginning teachers (E and I) appreciated the importance of finding out pupils' preconceptions and noticed the differences among the pupils, as they said:

> A greater difference is noticed between the right and wrong concepts they have held in science than in other subject areas. (Ebi2)
>
> For those who can tell very quickly, they actually know about the classification (of metals and non-metals). They may however use different criteria to classify the difference between metals and non-metals e.g. texture, colour. They do not use the criteria of heat transfer. (Ibi3)

The awareness of the pupils' preconceptions led to influences or adjustments in the teaching strategy of the beginning teachers. Three of the beginning teachers (B, I and E) described how they taught with the pupils' preconceptions in mind:

> If they know more, then some activities can be taken out. I would jump the simple ones...I can also go deeper if the pupils are more interested. (Bbi2)
>
> Maybe they have not thought about this...There are some influences. I may have to talk about this in more detail during the practical activities. If they have some knowledge about the content, one or two practical activities may be sufficient. Otherwise, more practical activities can be done to show the difference...I have done two today and one yesterday. If they know about this already, then I may skip one of them. (Ibi3)
>
> There are things that they do not understand or have wrong concepts about, I will try to adjust the arrangement and see how I can help them with these. (Ebi2)

This suggests that three of the beginning teachers (B, I and E) were more active in eliciting pupils' preconceptions and taking this into consideration in their teaching.

The beginning teachers were asked to describe how they stimulate pupils to think in the science lessons. Five main types of strategies were described: using an activity or experiment, asking pupils questions, using an analogy in the explanation, encouraging pupils to ask questions, and giving feedback to pupils' responses. The last four types were concerned with the interactions between the teacher and the pupils in the classroom. In describing the use of activities and practical activities, three of the beginning teachers (B, I and L) described their strategies:

> After the activity, they think about the questions. (Bbi2)
>
> It would be better if there are group activities. In the process, they will ask themselves instead of the teacher asking them. (Ibi3)
>
> Yes, I stimulate them to think about the experiment and see how they think, what their suggestions are. Though they may not think in the same way after the experiment, at least I know about these ideas and it may be easier for me to help them to change (their ideas). (Lbi3)

Though the experiment or the activity was used as a lead to get the pupils thinking, these teachers valued the interactions between the pupils as they conducted the group work, and the knowledge of how pupils think as elicited during the activity. The interactions between the teacher and the pupils were seen to be important by the beginning teachers. Beginning teachers I and B suggested how they made use of questions and an analogy to get pupils thinking:

> I give them some questions to think about. I will hold the answers and let them think about it. (Ibi2)
>
> By asking the question "why", this makes them think. (Ibi3)
>
> I used an analogy between the water treatment plant and the kidney and asked them to think about how the parts of the plant compare with the various functions of the kidney. Deeper questions can be asked. (Bbi2)

Another beginning teacher (L) described how she encouraged pupils to ask questions in her lessons:

> I let them ask questions and they would come up. This is how they used to learn and it becomes a habit. I would let them ask and our lessons are like this...If you let them ask, they will have more questions. . They have a lot of questions in my lessons. (Lbi2)

The following account of how teacher E handled pupils' responses reflected the way he acknowledged pupils' responses and his belief that telling did not necessarily lead to learning. His acceptance of the pupils' responses and the motivation to encourage pupils to think was described:

> When there is a practical activity, they can see the result themselves and talk about it. I do not need to tell them all the time. This may stimulate them to think. (How did you try to stimulate them to think in the previous lesson?) When they gave me a correct answer, I would not acknowledge it right away. I would pretend that it may not be correct, and stimulate them to talk a bit more about it or maybe give more reasons to convince me. (I have just seen that the pupils have given wrong answers just now, what you did was to ask them to remember their results. Why did you do this?) Originally, I planned to ask them to write down the results on the blackboard after they had completed the experiment. This allows a comparison of results or feelings from different pupils. However, there was not enough time and I used another way by asking them to conclude on who found different feelings in the two fingers (to measure temperature) .... (Why did you not just point out that they are wrong immediately just now?) I don't think that there is right or wrong answers with feelings. If I just tell them the right answer, the pupils may not be convinced. There is no right or wrong feeling. (Ebi2)

These beginning teachers (B, I, L and E) had given serious thought to ways of stimulating pupils to think. In this process, the interactions between the pupils in the activities and the interactions between the teacher and the pupils were found to be significant.

In helping the pupils to apply the newly learnt concepts, the beginning teachers (L and I) shared a view that the application has to be linked to meaningful contexts or related to their daily life experience, such as:

> As the pupils observe in their daily life experience, they can see which are the things that will expand on heating and contract on cooling. They can observe the things at home. (Lbi2)

> Look at something that will become hot at home, think about the design of the cooking pot, why the handles of the knives and fork are made in such a way, many things that they use at home. Thinking about the reasons behind their design...There are more opportunities to apply in the previous lesson on hot expansion and cold contraction e.g. the contraction of railway line, the flyover, there are more examples from daily life experiences. In this topic, there are discussions on household utensils.... I ask them to be more aware of things around them. (Ibi3)

The pupils were encouraged to be alert and relate their science learning with daily life experiences. Moreover, teacher B described an occasion when the pupils found out this relationship and how he handled the discussion in his teaching:

> The part on the heart, the last part is on how to test the heartbeat, to compare the pulse rate before and after doing exercise. After this part, the questions (from the pupils) are different. The pupils have a Physical Education lesson the next day; they asked me why the heart beats so fast after doing exercise. They ask me why they can feel the heart beat as they put their hands on the chest. I then teach them how to measure the pulse rate such that they can apply this in their daily life experiences. (Bbi2)

Apart from encouraging pupils to apply the science concepts verbally or during discussions, the beginning teachers (E and L) suggested using practical activities and worksheets to provide an opportunity for application during the lessons:

> As there are new practical activities, I ask them to explain the results based on what they have learnt in the previous lessons. They have to apply what was learnt on the new topic. (Ebi2)

> I try to complete the worksheets that you gave me last time. There is one in the resource pack that ask the pupils to distinguish which are the things that are made of iron or plastic, etc. (Lbi3)

The application of science concepts can thus become more meaningful for the pupils as these concepts are related to familiar contexts for the pupils.

The above analysis suggests that four of the beginning teachers (B, I, L and E) taught in ways that were congruent with a constructivist view of learning as they attempted to elicit pupils' preconceptions and to adjust their teaching with a knowledge of pupils' preconceptions. They valued the interactions between the pupils and between the teacher and the pupils in stimulating pupils to think. Raising questions and letting pupils raise questions were seen to be equally important. Moreover, science learning was found to be more meaningful as pupils could apply what they learnt in the classroom to their daily life experiences.

8.3.2 An overview of the lessons conducted by the beginning teachers

Each of the beginning teachers was observed twice during the implementation of the resource pack to find out the influence of the support provided. In order to find out to what extent the beginning teachers were teaching science with a constructivist view of learning, the lessons observed were analysed using the checklist of teacher actions that help pupils' conceptual change described in Chapter 6, Section 6.2.3.1. The list of teacher actions is:

i. Presenting questions for pupils
ii. Inviting pupils to ask questions
iii. Asking pupils to predict results of practical activities
iv. Illustrating by using a range of examples
v. Illustrating by using practical activities
vi. Relating new ideas with previous concepts
vii. Using newly learnt ideas in new situations
viii. Pupil initiated activity
ix. Clarifying pupils' ideas by using other examples

The number of matches between the teaching actions with the nine actions in the list was identified for each lesson. The numbers of matches in the lessons observed are summarized in Table 8b. The number of attempts varied quite widely in the two observations made during the implementation of the resource pack. It must also be pointed out that the attempts that the teachers made depended a lot on classroom situations and pupils' responses in the lessons. The representation is thus relative among the beginning teachers. Teacher D made fewer attempts during the two observations. Teacher B made the same number of total attempts as teacher D in the two observations, however, the low figure was mainly arising from the first lesson observed. The other three teachers had higher numbers of matches. In particular, teacher L conducted two lessons that were very simulative in helping pupils to think. The lessons conducted by teacher E showed a large number of matches. In the lesson that was observed before the implementation of the resource pack, he had made use of every opportunity to get pupils to make detailed observations and think actively. His mode of teaching was consistent and was based on a constructivisit view of learning.

When each of the teacher actions on the checklist was considered for all the five teachers (Table 8c), four of them occurred at higher frequencies: presenting questions for pupils, inviting pupils to ask questions, illustrating by using practical activities, and relating newly learnt concepts with previous concepts. Compared with the findings during the teaching practice, an increase in occurrence for inviting pupils to ask questions, conducting demonstrations, and relating newly learnt concepts with previous concepts was found. Three teacher actions remained at a comparable level of occurrence in the two phases: asking pupils to predict results of practical activities, pupil initiated activity, and clarifying pupils' ideas using other examples, with the first two occurring at low levels. Two other teacher actions showed a lower level of occurrence when compared with the teaching practice: illustrating by using a range of examples, and using newly learnt ideas in new situations.

Table 8b Number of attempts that the five beginning teachers made in the lesson observed to take into account pupils' thinking

Teacher	**Number of matches on teachers' action list**	**Total number of matches in the two observations when the resource pack was introduced**
B 1st observation	2	6
B 2nd observation	4	
I 1st observation	6	11
I 2nd observation	5	
L 1st observation	7	14
L 2nd observation	7	
E 1st observation	4	11
E 2nd observation	7	
D 1st observation	3	6
D 2nd observation	3	

Table 8c Summary of occurrences of teacher actions and the checklist for each teacher

Teacher actions	**B***	**I***	**L***	**E***	**D***	**Occurrence**
Presenting questions for pupils	✓	✓	✓	✓	✓	10
Inviting pupils to ask questions	✓	✓	✓	✓	✓	6
Asking pupils to predict results of practical activities	✗	✓	✓	✗	✗	3
Illustrating by using a range of examples	✗	✓	✓	✓	✗	5
Illustrating by using practical activities	✗	✓	✓	✓	✓	8
Relating newly learnt with previous concepts	✓	✓	✓	✓	✓	8
Using newly learnt ideas in new situations	✗	✗	✓	✓	✗	2
Pupil initiated activity	✓	✗	✓	✗	✗	2
Clarifying pupils' ideas by using other examples	✓	✓	✓	✓	✗	4

* These columns represent whether a certain action was found in the lessons of a particular teacher.

Comparing with the teaching practice period (section 6.2.3.2), there was an increase in the occurrence of inviting pupils to ask questions. This suggests that the beginning teachers were more confident with having questions from pupils and had given them more encouragement to ask questions. The beginning teachers were also clearer about the relationships between new and previously learnt concepts with the explanation in the resource pack and with their increased teaching experience. Hence, more explicit linkages between concepts were made in their lessons. Getting pupils to predict experiment results may mean taking up more time in the lessons and the beginning teachers were not too familiar with conducting the practical activities. They may have found themselves too occupied in arranging the apparatus as they started the practical activities and asking the pupils to predict results was placed at a lower priority. Under such circumstances, coping with conducting the practical activities was more important than getting pupils to think. Getting pupils to initiate activity was difficult for the science classes. The beginning teachers were still at a stage of trying to engage pupils in thinking, asking questions, and responding in the lessons. The beginning teachers provided a number of opportunities for the pupils to apply the concepts learnt to familiar contexts, and to them this application was meaningful learning as described in the interviews. It appears that the support provided by the researcher or as a teacher educator facilitated their science teaching, such that more attention was paid to strategies consistent with a constructivist view of learning.

On the whole, the analysis in Table 8c suggests that three of the beginning teachers (teachers I, L and E) had attempted seven or more of the actions on the checklist. Teacher B tried five actions on the list and D implemented only four on the checklist. One of the observed lessons, which was conducted by teacher B, turned out to be quite unsuccessful due to the limitation of time and the arrangement of the classroom. This may explain the lower level of implementation, whereas the situation for teacher D was quite different. The interview findings tend to show that her belief in science teaching was more influenced by the school context. Though she realized the ways the constructivist view of learning help pupils' conceptual change, she found it more important to get pupils to remember the content and obtain high scores in the examinations. This may explain why her practice did not show a large number of matches with the checklist for teacher actions that help pupils with conceptual change.

8.3.3 The lessons conducted by each of the beginning teachers

In order to find out whether the support provided had helped the beginning teachers to teach science based on a constructivist view of learning, this section describes the observed lessons of each of the teachers. Instead of explaining the quality of the teacher actions as in Chapter 6, this section looks at the situation on a case by case basis in an attempt to reveal what each beginning teacher implemented the resource pack and how the responses of the pupils were like. The findings were obtained from the transcriptions of the lessons observed and the researcher's field notes.

8.3.3.1 Lessons taught by teacher B

Teacher B was teaching a class of primary four pupils and the topic was on "the body". During the two lessons observed teacher B attempted five of the teacher actions on the checklist for helping pupils with conceptual change. These five actions were:

- presenting questions for pupils;
- inviting pupils to ask questions;
- relating newly learnt with previous concepts;
- pupil initiated activity;
- clarifying pupils' ideas using other examples.

In the lessons observed, the pupils raised a number of questions relating to the structure and function of the brain as well as questioning about the organization of the organs in the body. For example:

> T: What do we call the middle part of the brain?
> P: The mid-brain. What is the function of the mid-brain?
> T: We will talk about this later.

> Now put the pictures that you have just used together. (Pupils put them together and revise the parts again by themselves.)
> T: Now we use another pile of pictures and knowing the structure of the brain, we try to learn about their functions. Now take out the main brain.
> (Pupils ask questions about the different parts of the brain.) (Bbo2) (see Chapter 3, section 3.4.2 for a description of the coding)

In this way, teacher B presented a number of questions as he taught the topic. During the second lesson observation, the pupils were asked to draw the organs inside the body on a large piece of paper. A number of questions and suggestions came up in some of the groups, such as:

> One of the groups draws in the diaphragm (an organ not taught in the previous lessons). ...During the group work, the pupils suggested that the size of the heart is not correct in the picture, it should be the size of a fist. (Bbon3) (see Chapter 3, section 3.4.2 for a description of the coding)

While relating the concepts is important, in the last lesson, the pupils did not see the relationship between each of the organs or the organ systems or how they were organised in the body:

> In the drawings, most of the groups have put in the digestive system but the pupils have separated the organs from one another. (Bbon3)

After the pupils showed their drawings to the class, the teacher tried to help the pupils to relate the newly learnt ideas with previous concepts, such as:

> T: The oesphagus and the trachea. The trachea is then divided into two branches and connected to the lungs. Why are the lungs like this? The shape is funny. Where are the lungs? (Chest) The positions are correct in general. Next the heart, we have talked about the position in the previous lesson, I have said that it is near the left side of the chest. Many draw it at the middle. One draws it under the lungs. The liver is underneath. The diaphragm is there but the shape is incorrect. (Pupils keep shouting out answers.) The stomach is near the left; you draw it at the middle. The large intestine is in the lower part. The liver and stomach is missing here. The small intestine is surrounded by the large intestine. Then there is the urethra; most of the groups have put this in. What is missing? (Pupils volunteered information.) The urinary bladder and the kidneys. Note the positions of them. (Bbo3)

> The pupils were very happy and put their hands on different parts of their body to show the position of the organs. (Bbon3)

This quotation occurred at the end of the activity when the teacher tried to summarize the pictures that the pupils had drawn. In this discussion, he tried to relate the organization of the different organs in the body and discussed their relative positions. For the pupils, they put their hands on the body trying to relate what was learnt in the lesson with their own "feelings" of where the internal organs were inside their own body. While the pupils might have a view that the organs were separated in the body, teacher B clarified their ideas by posing a counterview that they were linked and were related to each other.

In general, the pupils were engaged in the two lessons. One of the lessons observed started 10 minutes late leaving the teacher with about 25 minutes. The classroom was so crowded that the overhead projector could not be used. However, the pupils had an enjoyable time working on the puzzles for the different parts of the brain:

> The teacher attempted to arrange a range of activities in the lesson and make the lesson interesting. However, due to physical constraints and the time available in the lesson, the teacher was not able to follow-up on pupils' ideas. (Bbon2)
>
> Pupils found the lesson interesting. They were active and were involved in the whole lesson. The pupils were talking about the topic, trying to locate the pieces (of the puzzles about the parts of the brain) and were aware of the funny names of the parts of the brain and their position. (Bbo2)

In the second lesson when the pupils were asked to draw the internal organs into an outline of the body shape, the pupils were able to accomplish the task and kept discussing among themselves. After the activity, they came to realise the relative positions and the relationship between the internal organs in the body:

> The pupils started the group work and were very excited about the activity. Some asked if they had to fill in colors on the picture. Some lay on the paper to draw the outline. (Bbon3)
>
> The group work was quite efficient. The pupils were able to draw in most of the organs inside the body and have a happy time working together, moving around, checking on other groups and were talking about the positions of the organs. The teacher needed to control the noise level of the class from time to time during the activity. (Bbon3)

Due to the constraints of limited time and the setting in the classroom, the first observed lesson was not as thought-stimulating. In the second observation, most of the time in the lesson was spent in the group activity of having pupils to draw the internal organs, hence the time spent in the interaction between the teacher and the pupils as a class in discussion, and raising questions was short. Because of this, a smaller number of teacher actions were identified. Despite these, teacher B was observed to be aware of the importance of getting pupils to participate in the group activities, let them ask questions and helped the pupils to relate different concepts learnt on the topic.

8.3.3.2 Lessons taught by teacher I

Teacher I taught a class of primary two pupils on the topic heat and she was also the class teacher of the pupils. Among the two lessons observed, she had implemented seven of the nine teacher actions on the checklist, which were:

- presenting questions for pupils;
- inviting pupils to ask questions;
- asking pupils to predict results of practical activities;
- illustrating by using a range of examples;
- illustrating by using practical activities;
- relating new ideas with previous concepts;
- clarifying pupils' ideas using other examples.

She taught by following closely the suggestions in the resource pack and the response from the pupils was good as they raised a number of questions in the lessons. She presented a number of questions for the pupils to think about during the lessons such as:

> T: We have seen different ways of producing heat. For example, the light bulb, the heater produced heat by electricity. Switching them on we feel the heat. Secondly, we have the candle, heat is produced by burning, thirdly, for the hands, heat is produced by friction..... After you eat and digest, your body will produce heat and you feel warmer. Now answer the two questions under the pictures. How is heat produced? Can you suggest other ways of producing heat? You can write down what you think. I now give you two minutes to think about it.
> T: Besides these, can you think of other ways to produce heat?
> P: Using the alcohol lamp. (Ibo2)

This happened after a discussion about different ways of producing heat. The pupils were given some time to think over the points that the teacher had concluded and to put in new ideas of heat production on the worksheet. The following questions were raised after a practical activity, in which pupils used their fingers to test out the temperature of water:

> T: So some of you put that left is cold and right is warm. These are not surprising. Now I have two questions for you think about at recess. They are found in the conclusion part of the worksheet. Why do you have different feelings of hot and cold? Secondly, how can we measure temperature? (Ibo2)

Apart from asking the pupils to explain their findings, teacher I also encouraged the pupils to predict the results of practical activities as in the following:

> T: What do we know from the practical activities? Do you think that heat is transferred from one end to the other gradually or that the whole ruler gets hot at the same time? Who said it is the first answer, raise their hands. (Most of the pupils) Who think that the whole ruler gets hot at the same time? (A few raised their hands.) Was ABCD hot at the same time? (Ibon2)

Teacher I tried to arrange a number of group activities for the pupils, however, there were not enough thermometers in the school. She thus set up a number of stations for the pupils to try using thermometers to measure the temperature of water. This attempt for group activity encouraged the pupils to talk about measuring temperature and their feelings of hot or cold:

> The pupils grouped around the stations, taking turns to read the temperature. The pupils put the thermometer in the cups and measured the temperature. The pupils talked about how to read the temperature. (Ibon2)

Her attempt to use group activities despite the lack of resources was unusual among the primary teachers. The activity would have turned into a teacher demonstration for most of the teachers. Her enthusiasm and motivation for getting pupils to participate in the lessons was strong. In the following activity, the pupils used four cups containing water at different temperatures to pretend that they were drinks or the bath water and measured their temperature. This activity provided another example of temperature measurement and showed the relationship between the temperature and the hotness of liquids:

> The teacher used four cups to represent the four pictures on the worksheet (the lemon tea, the bath water, the hot soup and a cup of tea.) There were not enough cups around and only three stations were set up in the room. (Bbon2)

Teacher I had also tried to help the pupils to relate the newly learnt ideas with their previous concepts:

> T: We then look at the competition of Mr. Heat. His mission is to carry heat or energy from a place with higher temperature to a place with lower temperature. He is filled with power and starts at the hot place to the other end. The cooler places then warm up gradually. Different types of materials represent different tracks. The metal is a smoother track and the plastic one is rougher. It is easier to run to the finish on metal. For the plastic, there are a lot of roadblocks in the middle of the road. It is therefore more difficult. In which cup does the ice melt first? (referring to the picture with ice in three cups made of different materials) One of the bowls is made of glass, one made of metal and one is plastic. Can you guess which one is the quickest? (Metal) (Ibo3)

In this quotation, teacher I helped her pupils to clarify their ideas about which are the parts that produce heat. In the first part of the quotation, the teacher was trying to explain how heat was transferred using an analogy. In the second part, she attempted to relate the idea of heat insulation with heat transfer in metals and non-metals with heat insulation.

Teacher I was also aware of helping pupils to distinguish different ways of heat production and clarify their concepts. In the following lesson, she helped the pupils to identify which were the exact sources of heat production:

> T: What will pass through the light bulb after that?
> P: Electricity.
> T: Yes, there must be electricity. If there is no electricity, will the bulb light up by itself? (No) When there is electricity, it will produce light and heat. The second one is the heater. Where do you colour?
> P: The fins at the side.
> T: Yes, not the other parts. The heater is hot. If you do not switch it on, it has to rely on..(electricity) to produce heat. Is the on/off switch hot? (No) The third one is the candle, where do you colour?
> P: The fire part.
> T: So how does the candle produce heat, it is electricity this time? (No) Then what is it?
> P: Fire.

> T: That is by fire and burning to produce heat. The electric kettle, I saw Janet has coloured the whole kettle, has anyone coloured the whole kettle like her? (About 10 raised their hands.) I would like to ask others who did not colour the whole kettle, where did you colour?
> P: The snaky part at the bottom. (Bbo2)

In the lessons observed, the pupils raised a number of questions and one of them was an extension of the topics covered:

> P: Why can heat make things melt? (Bbo3)

Pupils' participation in the two lessons observed was active. The researcher noted that they were interested and engaged in the activities most of the time:

> The pupils have a good time running around, talking about the thermometer and looking at the rise and fall of the thermometer. The pupils recorded the temperature on their worksheets. (Bbon2)
>
> The pupils were excited to watch the experiment and some even got out of their seats to take a better look. The teacher poured the hot water into the box before putting in the rulers. (Bbon3)

On the whole, teacher I provided a number of opportunities for pupils to work in groups and arranged for group work despite the lack of resources. The pupils were interested and excited about these opportunities. Teacher I followed closely the content of the resource pack in her teaching and had succeeded in stimulating her pupils to think, getting their responses and questions.

8.3.3.3 Lessons taught by teacher L

Teacher L taught primary two and the. topic was heat. She was observed to be very interactive in her teaching and the pupils were also seen to have adapted to the way she stimulated them to think in the lessons. There were a large number of questions raised by the pupils. They were also able to respond to the teachers' questions and some of them could follow-up on the subsequent responses and raise further questions. The findings included a number of instances of teacher-pupil interactions, which showed that the pupils were actively engaged in thinking in the lessons. Among the five beginning teachers, teacher L was the only teacher capable of effecting this interaction in the science lessons. From the list of the nine teacher actions to help pupils' conceptual development, she attempted all of them in the two lessons observed.

Teacher L presented a question for pupils to think about as she demonstrated a practical activity on the different rate of heat transfer in different materials:

> P: Do you know which one is going to be the fastest?
> T: Well, let us look at it. Which one makes the butter melt the quickest?
> P: The iron. We cannot see very well. That is iron. (Pupils are very excited to see the result.) (Lbo3)

The pupil who asked the question actually prompted the prediction. On another occasion, Teacher L encouraged the pupils to predict the results of the experiment and made use of the empty space in the textbook for the pupils to put down their prediction:

> T: Well, now in part 3. There is a cup with several rods in it; wood, iron, plastic and glass. We want to know which one is the quickest conductor, write 1,2,3,4 onto it. At the same time, I will try this out in this cup.
> P: Is the pencil going to be very slow?
> T: Just write down the order you think. Think about this on your own, I would ask one of you to touch the rods and see which one is the fastest to get hot.
> (Pupils asked many questions about the prediction. (Lbo3)

Before the experiment that illustrated the working principle of the thermometer (using a small plastic bottle fitted with a drinking straw), teacher L asked the pupils to predict the result and they came up with a number of possibilities:

> T: Now look at the water level at the blue mark here. How do you think the level will change if I put it into hot water?
> P: The level will rise.
> P: The plasticine will open up.
> P: The level will fall.
> P: The plasticine will expand.
> The teacher repeats the possibilities. The teacher then performs the experiment and walks around the class. The pupils see that the level has risen. (Lbo2)

Being aware of the pupils' predictions, she helped them to understand the principle and clarify their ideas by proposing a counter view of the changes of the water column in hot and cold water:

> T: How is the water level at the blue mark?
> P: Higher.
> T: Why is it higher?
> P: Our hands are warm and keep it warm.
> T: Yes, we now put it into cold water. What will happen?
> P: It gets higher.
> T: Do you watch the weather report or have you noticed the thermometer on the wall? Try to read the temperature at different days and see if it rises or falls. Now look at the water level.
> P: When you place it in hot water, you have to push onto it to get it expanded.
> T: Why does it rise when it is in hot water and drop in cold water?
> P: Because it is hot and it rises. This is like the weather, if the temperature is high, the thermometer rises, if it is cold, it falls.
> T: Yes, Mary suggests that because it is hot and this makes the water rise up and if it is cold, then the water in the straw falls down. (Lbo2)

During the teaching process, teacher L used a number of examples to help pupils to build their concepts. For example, in the part on expansion and contraction, she continued with another problem for pupils to think about:

> T: The things will expand when it is hot and shrink when it is cold. Have you seen mummy trying to open a tight can that was taken out from the refrigerator? Who has seen this? What does your mummy do next?
> P: Use a knife to open it.
> T: Is there any other way to open it?
> P: Mummy puts it in hot water and tries to open it again after a while.
> T: Have others seen mummy trying to open the can with this method? (Lbo2)

The pupils raised a number of questions during the lessons, in the following conversation one of the pupils proposed a counterview to the teacher that not all the things expand on heating:

> T: When the things are hot, they expand and become bigger.
> P: But I have seen things shrinking after they are placed inside the microwave oven?
> T: Well, the sausage shrinks because water has come out of it after it was placed in the microwave oven. But they expand on heating in a barbecue. This means that... (Lbo2)

Another question raised by the pupils trying to clarify whether the principle of expansion works with larger number of balls and a larger basin of hot water:

> P: Mummy says that if the table tennis ball collapses, you have to put it in hot water and cover the cup.
> T: Yes, but I don't have a cover here. Well, the ball has recovered its shape. Take a look at it. I will ask Joanne to check it out for me.
> P: Will the same thing happen if there are lots of balls placed in a large basin of hot water? (Lbo2)

The following was raised at the end of a lesson and the pupils were eager to know how to apply the concept of heat transfer to cooking utensils. They initiated a discussion about the results of heating plastic or glass cookware instead of just looking at heat transfer in these materials:

> T: That means heat is transferred best in iron. When we cook, what is the cooker made of? (Metal) Yes, heat is transferred quicker in metal. We will talk about the other parts tomorrow.
> P: Can we use plastic to cook? Or will the pot explode if we use glass?
> T: Plastic will melt as we heat it.
> P: Can we use glass?
> T: We do not use glass, what will happen to it at high temperature?
> P: It will explode. (Lbo3)

Teacher L described how she valued pupils' questions in class and found that this was a way to understand pupil learning:

> I have not thought about a set model (in science teaching) but I think this is better and allows pupils to build their concepts.... I have always taught in this way. But there is one problem with this, the pupils can get easily off-task, they like to ask nonsense questions. If you do not let them speak out, they get very uncomfortable. (Which will you choose?) I know that they want to say something unrelated and let them do so from time to time. It is better this way, because if I am the only one talking, I cannot tell how much they have learnt and it is not very good that way. (Lbi3)

The above conversations between the teacher and the pupils suggested that teacher L was interactive in her teaching. She was aware of pupils' responses and that the pupils had adapted to this teaching style and were thinking actively in the lessons. Unlike teachers B and I, there was no group activity and all the practical activities were done in the form of teacher demonstrations. In the interviews, teacher L explained the lack of group activity as due to classroom management problems.

8.3.3.4 Lessons taught by teacher E

Teacher E was teaching a class of primary two pupils on the topic of heat. He was different from the other beginning teachers in that he was also the coordinator for the GS (General Studies) subject and had shared the materials in the resource pack with seven other teachers in the school. Among the list of nine teacher actions that helped pupils with their conceptual change, teacher E performed seven of them, which were:

- presenting questions for pupils
- inviting pupils to ask questions
- illustrating by using a range of examples
- illustrating by using practical activities
- relating new ideas with previous concepts
- using newly learnt ideas in new situations
- clarifying pupils' ideas by using other examples.

In the first lesson of the topic as teacher E asked the pupils to consider the different sources of heat production, he guided their thinking by presenting two questions:

> T: Yes, the thermometer can test both hot and cold and tell us the hotness or the coldness of the substance. Then, we talk about heat, what are the things that produce heat in our classroom? (Ebo2)
>
> T: Well, we have noted a number of things that produce heat in the classroom, let's look at our home and see what are the things that produce heat. (Ebo2)

These questions led the pupils to consider systemically examples that they saw in their daily life experiences. After a practical activity on feeling the temperature of water with the skin, he raised a question to get pupils to conclude the results:

> T: The others found that the temperature is different for the same cup of water. What does this tell us about using our skin to measure the temperature? (Ebo2)

Teacher E attempted to use a number of examples to illustrate how temperature can be measured as he introduced also the use of the alcohol thermometer:

> T: What is the difference between the two thermometers here? What is the colour here? (Red) What is inside? (alcohol) There is another thermometer here, let us look at it. Can we read the temperature at once? (It has to go up slowly.) (Ebo2)

In an activity on classifying the things inside the pupils' pencil box, the pupils asked the teacher how to classify a pair of scissors. They finally came to the following conclusion:

> The teacher then asked the pupils to take out their pencil case and put the things that are made of metal inside the box and those that are made of non-metal outside the box. The pupils asked the teacher about how to classify a pair of scissors. Some suggested that they should put the metal part inside the box and the non-metal / plastic part outside the box. (Ebo3)

This illustrated that the pupils were actively thinking about the criteria for the metals and non-metals. At the end of the topic on heat transfer, teacher E tried to help the pupils to use their newly learnt ideas in new situations and presented a problem case for the pupils to find out the answer from a practical activity:

> The teacher asks each group to take the materials: a paper cup, a plastic bowl, a ceramic spoon, a plastic spoon, a metal spoon and a wooden chopstick. The pupils go to take the materials and are very interested to participate...The pupils are very excited talking about the experiment, taking turns to try. The teacher walks around and tells the pupils where to touch the spoon and which is the level to feel the hotness of the spoon. (Ebon3)

In this activity, the pupils had to feel by themselves, which spoon or chopstick transferred heat quickly and attempted to explain the reason, applying what was learnt in previous lessons.

The pupils were engaged in discussions with the teacher and were able to relate what they learnt with their daily life experience:

> T: Why is the spoon made in this way? Can it not be made of iron for the whole spoon?

> P: If the whole spoon is made of iron, it will burn your hands if you hold it.
> T: Why will this happen?
> P: Because iron conducts heat very quickly.
> T: How do you know this?
> P: The teacher in P.1 taught this.
> T: Do others remember this?
> P: Yes. Also on the TV.
> P: The handles on the pedestrian are also very hot.
> P: They are under the sun.
> P: The sun can be hotter than a fire. (Ebo3)

On another occasion, the pupils were asked to suggest explanations for an unexpected result:

> The clip at the furthermost end from the flame did not fall last as expected. The teacher asked the pupils why. They said that the teacher has put on too much butter at that position. Some suggested that the paper clip was not well stuck on the butter at the end. (Ebo3)

The pupils were asked to describe a practical activity that they had done in a previous lesson and they were able to suggest a number of possibilities in explaining the results:

> Next, we have also looked at the expansion of liquid, what did we do then?
> The pupil describes the small bottle experiment and said that the bottle was put into hot water and then they saw the water level inside the bottle rise. The pupils said that the water too hot and the water level rose like that in the thermometer.
> T: Why did the water level rise?
> The pupils suggest a number of reasons including:
> - air expands
> - it is light
> - the air goes up from the hot water. (Ebo3)

These examples indicate that the pupils were responding to the teacher's questions and were engaged in thinking throughout the discussions with the teacher.

On the whole, teacher E attempted to stimulate pupils to think in the lesson and the guiding questions were well thought of. He accepted pupils' responses and although some were not expected answers, he was open and let the pupils voice their thinking. The pupils also responded actively to the questions, thinking and suggesting a number of possibilities. Though he made use of the materials in the resource pack, the implementation details (e.g. how the paper clips could be stuck onto the metal ruler) were modified to make the practical activities work better in the classroom situation. He also added in a number of activities e.g. the classification of the metals and non-metals and the last activity on asking pupils to feel the heat transfer in the different spoons, and discussions e.g. the use of the alcohol thermometer to enrich the lessons. The questions raised, the arrangement of the activities, and the way the practical activities were conducted, reflected that he had preferred detail planning of the lessons. The way the pupils responded to the questions showed that he had been encouraging them to participate, answer questions and ask questions.

8.3.3.5 Lessons taught by teacher D

Teacher D taught at primary two level on the topic of heat. In the interviews, she related concerns about getting pupils to remember the text and score high marks in the examinations. She described how she worried about using a candle in the classroom as other teachers might pass by and see this. The conduction of practical activities was uncommon in the school and the use of a candle might raise safety concerns among the teachers. She expressed a feeling of uneasiness about this. She would not want to teach in a way that was too different from other teachers in the school. For most of the time, she was following the textbook in her teaching and she attempted three of the activities from the resources pack. Among the list of nine teacher actions helping pupils conceptual change, four were identified in the two lessons observed. They were:

- presenting questions for pupils
- inviting pupils to ask questions
- illustrating by using practical activities
- relating new ideas with previous concepts.

There were teacher-demonstrated practical activities in the observed lessons but there was no group activity or discussions among the pupils. The mode of the lessons was mainly teacher demonstration, teacher questions and pupil answers. Questions were presented to get pupils thinking about the topic, such as:

> T: We first discuss something about heat. It is a bit cooler these days and we wear thicker clothes like what I wear today. Besides wearing more clothes, how can we get ourselves warmer? (Dbo2)

This question started off the topic about heat production and following this question, the pupils offered a number of ways in which heat could be produced.

In trying to get pupils to understand the concept of heat transfer, teacher D started with an explanation about the hot cooking pot:

> T: Have you realized what the pot is made of? It is made of metal and mum will use a piece of cloth to insulate the heat from it. Well, the cloth can actually insulate the heat. There are other things that conduct heat, like the metal pot.
>
> T: There are things that conduct heat like the pot, it is in touch with the fire and so it also becomes hot. The pot is actually made of metal. Like the leg of the chair, it is also made of metal. (Pointing to the table) These are made of wood. (Writes on the blackboard, metal: copper, steel, iron) (Take out a ruler) This is also made of steel. Other examples are keys, made of metal. Other things are not made of metal, like plastic (write on the blackboard, non-metal) (Dbo3)

Teacher D then related the pot with things made of metal and introduced the concept of metal and non-metal. After these explanations, she started with a demonstration to show the transfer of heat in metals and non-metals. In the last part of the lesson, she helped the pupils to realize how the metal of the cooking pot helped to conduct heat and explained why mother had to carry it with care after cooking. The teaching sequence and the way the topics were introduced were logical and related. However, the lessons were dominated by teacher-talk and there was little interaction with the pupils. Most of the time, it was her explanation and introduction about the topics or concepts. There was no group activity or discussions, the pupils sat most of the time listening to her explanation. In the two lessons observed, the only question raised by the pupils was whether water boils at 100°C.

Teacher D made use of the activities suggested in the resource pack and conducted the practical activities in forms of teacher demonstrations. She also followed the discussion questions in the worksheets to help pupils to build up their concepts. Despite these efforts, the lessons were not as interactive and the answers or suggestions that the pupils offered were limited in the lessons. Teacher-talk took up most of the time in the lesson and the pupils raised few questions. As stated in the interviews, teacher D reflected that the two influences of the resource pack on her science teaching were that it gave her more ideas about alternative practical activities and reminded her at the arrangement of the topics.

Comparing the five teachers, the lessons of teacher L were the most interactive, in which the pupils were actively engaged in thinking, responding to questions, considering teachers' explanations, and raising questions again. The lessons observed of teacher E were planned in detail with modifications about the implementation and inclusion of more discussion activities. The pupils were also responsive and able to offer constructive answers to the teachers' questions. Teachers I and B closely followed the suggested contents in the resource packs and though there were teacher-pupil and pupil-pupil interactions in the lessons, the demand for pupils to think and respond in lessons were not as great as for teachers E and L. The teaching of teacher D was dominated by teacher-talk and her teaching was not interactive. Though there were teacher questions, and the teacher demonstrations and the topics were introduced in a sequence that considered conceptual development, there was little response or few questions from the pupils and the lessons were dominated by teacher-talk.

8.3.4 Perceived influence on the teaching of the beginning teachers

In order to find out if the teachers had a constructivist view of learning in mind as they taught, this section reports on how the beginning teachers thought their teaching was different when they used the resource pack. The findings are summarized from the interviews with the beginning teachers. The beginning teachers found their teaching not so closely bounded to the textbook, not resulting in rote learning in their pupils, including more activities or practical activities in classes, knowing about pupils' problems in learning, and planning based on a topic sequence different from the textbook.

The beginning teachers (D, L and E) described their science teaching in the past as closely following the textbook most of the time. For example:

> (Usually) I follow the sequence in the text. (Ebi2)

The implementation of the resource pack made it different as:

> I would not have thought of doing such a practical activity. There is a different way to teach, but I will also look at what is included in the textbook. See if there are simpler and achievable practical activities to prove it. Before, I had to refer to the textbook and I may not have thought of any other things. (Dbi3)

> There are more activities. There may be things that are not found in the school. If I just read from the textbook about a practical activity using candles, I may not do it and may just tell the pupils about it. (Lbi3)

> The pictures and the practical activities may not be so rich. I would use the contents in the textbook as the main source. At most, I will try to find out the old video tapes or the videos provided by the Education Department and have a look. (Ebi3)

During the first round of interviews in the beginning teaching phase, the beginning teachers reported that the textbook was usually used as the predominant if not the only source of information during their lesson preparation. The introduction of the resource pack provided a wider variety of ideas for activities, practical activities and different ways of teaching. Teacher B described how rote learning was replaced with the introduction of the resource pack:

> The pupils will have to remember the names by rote and it is boring. (With the resource pack) the impression[1] is deeper as the pupils have a chance to work on the puzzle. (Bbi2)

From this quotation, teacher B found that the teaching has a stronger impact on the pupils. Teachers B and L noted the inclusion of more activities in their teaching:

> There are more activities. There are much more activities in this topic than the others. (Bbi2)

[1] The word "impression" is a literal translation of the word used by the teacher. The meaning is having a strong impact on the pupils.

> I have a fresh look at this topic on the body. There are many activities that I have not thought about before. These are very good. (Bbi2)
>
> More practical activities will be performed. There is no metal ball or thermometer in the school. I would just talk about them and was ignorant that there are other possible practical activities or ways of conducting the activities. (Lbi2)

From the above, teacher B found that besides the activities, the resource pack has brought him to look at the topic from a new perspective. The difference in perspective was elaborated as teacher E explained that he was more aware of pupils' problems in his teaching and he adjusted the content accordingly:

> This time I have extra materials and know what the pupils may have problems with. I will add something in my lessons, these may not be found in the textbook or I may not have thought of these before. (Ebi2)

Teachers I and L noted that they obtained more content knowledge from the resource pack and Teacher I realized the importance of lesson preparation, a task which she did not have much time to accomplish in the first term of teaching:

> As I read the materials and the activities, I identify the wrong concepts that I have and correct them. There are things that I am not so clear about and having read the materials, it gives me more background information. (Lbi2)
>
> Preparation is also very important. I should have tried out the practical activity before the lesson just now. I was lazy and thought that it should go well. However, there is some difference with the results and I have to try again. The preparation and knowledge on the topic are important. (Ibi3)
>
> The resource pack has helped the teachers to understand more about the topic. (Ibi3)

These teachers related how the materials on science content helped them to clarify their own ideas and they also saw the importance of lesson preparation. Three of the beginning teachers (E, I and D) were teaching in a topic sequence different from that in the textbook which was very uncommon among the primary teachers:

> The sequence of topics is different and I will try to use activities to bring out the concept instead of just telling them. (Ebi2)

> The textbook talks about what are the things that produce heat, then the thermometer and goes back to the feeling on temperature using fingers. I think there is a problem with this, feeling the temperature after introducing the thermometer does not seem to be very appropriate. It is better to reverse this, the argument is that as it is not accurate using the fingers, we use the thermometer. (Ebi2)

In the process of teaching, teacher E was able to explain how the topics were arranged instead of just following what was suggested in the resource pack. The re-arrangement was made with an aim that supported the pupils' conceptual development:

> I used to consider only what is in the textbook and followed the sequence in the textbook. Now I may look at the sequence and method in the resource pack. (What is the relationship between them?) I feel that it is better to build up pupils' concepts gradually. The textbook may have a different sequence. (Ebi3)

For teacher E, the resource pack provided a suggestion about the sequence and the method to teach the topic. The topic "heat" was also given a more thorough treatment as problems related with insulation were also discussed:

> I will certainly do fewer practical activities. (without the resource pack) (What are the ones?) For example, those on insulation of heat will be skipped. These are not really emphasized in the textbook. However, these should be useful as insulation is related to the transfer of heat. (Ebi3)

Teacher I was aware of the inclusion of the basic concepts, heat and temperature, in her teaching and these were concepts that "may affect" pupils learning subsequent ones. The notion of helping pupils with conceptual development was considered in her teaching:

> (Without the resource pack) I will follow the books more and will not talk about heat and temperature. I will start with hot expansion and cold contraction. I will use the practical activities in the book and maybe the resources in the school. (Do you think it necessary to teach heat and temperature?) Well (pause to think), if time allows, I think that can be covered as something in addition. But if that was not taught (on heat production) that may affect how pupils form the concept of hot expansion and cold contraction. (Ibi2)

Similarly, teacher D appreciated the sequencing of the topics and how they were built on each other. She was aware of the importance of the basic concepts. Realizing the links, the basic concepts were covered:

> It tells me how to sequence the topics, the pace of teaching, and the arrangement of activities. The sequence of arranging them is good, from simple to difficult. (That is with the development of concept.) Yes, from simple to difficult. (You would be clearer about that.) Yes, otherwise, I would just read the topic in the textbook, it reads here (Hot expands and Cold contracts), I may jump very quickly to expansion and contraction, and cover little about heat. However, I am doing something different now and would not go to expansion etc. until the third lesson. (Dbi2)

The differences in teaching described by the beginning teachers can be seen as a departure from a textbook bounded strategy. The beginning teachers noticed the inclusion of basic concepts and the sequencing of the topics in order to help pupils with their conceptual development. Their teaching became more congruent with a constructivist view of learning.

8.3.5 Summary

This section has described the teaching strategies as reported by the beginning teachers in the interviews. The description was followed by an analysis of the lessons taught as observed in the lesson observations. The last part summarized the perceived influences on the teaching of the beginning teachers as related in the interviews.

The beginning teachers had attempted to stimulate the pupils to think in class mainly through the interactions with the pupils using questions, activities and practical activities. The application of the newly learnt concepts was achieved by referring to daily life experiences. The beginning teachers also found that in order to make science learning meaningful, the ideas have to be related to familiar contexts and the life experiences of the pupils.

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Regarding the influences of the resource pack, the beginning teachers suggested that the resource pack had helped them to notice the importance of the topic sequence in teaching. This made their teaching different when compared with how other teachers taught. They were more aware of the place of basic concepts in affecting the learning of new concepts. They found the suggestions for activities helpful and the presentation of the resource pack has helped them to come to look at the topic with a new perspective. It appears that the resource pack and the support provided facilitated the science teaching of the beginning teachers such that it is more congruent with a constructivist view of learning.

Having described the teaching when the resource packs were implemented, the next section looks into the learning in the lessons.

8.4 Science learning in the lessons using the resource pack

It is important that the beginning teachers perceived better learning among the pupils such that they found teaching science with a constructivist view of learning a worthwhile attempt. This section describes the science learning in the lessons while the beginning teachers were using the resource pack. Pupils' learning in the lessons is discussed in terms of the learning conditions and the learning outcomes.

8.4.1 The learning conditions

In terms of the learning conditions, all the teachers noticed that the pupils were more enthusiastic in the lessons. Comments stating that the pupils were participating actively, and being enthusiastic in the activities were often mentioned in the interviews and the journals, such as:

> Most of the pupils participated actively in the lesson though some of them had difficulty in following the instructions and could not get the expected results. (Ej2)
>
> In the experiment, the pupils were very anxious to see the result. Pupils asked what would happen if the bottles were taken out of the hot water. (Ej2)
>
> The pupils were participating actively and they understood the content well. (Dj2)

> They (the pupils) are more involved with something attractive for them. (Dbi3)

The active participation may be linked with a good learning atmosphere. Teacher B also noticed the difference in the learning atmosphere among the pupils as he described:

> The lesson is successful:
> ...A good learning atmosphere is cultivated. (Bj2)
>
> The lesson is interesting...This has helped to create a lively learning atmosphere. (Bj2)

Two of the beginning teachers also found the pupils more interested in the lessons, such as:

> For this activity, the pupils have to draw, they are more interested. (Bbi3)
>
> Most of the pupils are interested about the feelings of hot and cold. (Ej2)

Teacher D described the pupils as not feeling so bored in the lessons:

> They find what the teacher is doing is different from the textbook. The experiment may not be one of that in the textbook. They think this is special...They are happier with the practical activities and do not feel so bored when there is information not included in the textbook. (Dbi3)

The pupils were interested in learning other information not in the textbook, showing their motivation to learn. Teacher I summarized the learning condition as:

> I think that they are more active. They are noisier in lessons. They are also quite interested. (Ibi3)

In terms of creating better learning conditions, Teacher B found that the implementation of the resource pack helped to build up a better relationship with the pupils:

> There is more contact with the pupils. I walk around to help the pupils in the group activities and hence have more contact with the

> pupils. Before, I talked to the pupils in a large class in the lessons. I can talk to the pupils in the groups and have a better relationship with them. (Bbi3)

It appears that teacher B had more interactions with his pupils. Moreover, pupil-pupil interactions were important as teachers B and E described how they valued the opportunities for pupils to engage in group discussion, talk about results with each other and learn together such as:

> Now by dividing the pupils into groups and drawing, the pupils have a chance to think by themselves. The involvement and participation of the pupils is greater. (Bbi3)

> The pupils are able to observe the process of the experiment carefully and talk about the results of the experiment. Some of the pupils requested me to repeat the experiment. (Ej2)

> If the experiment is demonstrated in class, the discipline is not so good. It would be better to give them a chance to try by themselves and then everyone has a chance to a share. (Ebi3)

Besides having pupil-pupil interactions as improved conditions of learning, Teacher L related how the interactions between the teacher and the pupils helped pupils to learn better:

> If what they ask is around the topic that I am talking about, not nonsense questions, then they are on-task. Though what they ask may not be too related to what I am teaching, but it is still something that they think of themselves, this still shows that they are thinking. I will let them ask questions like this. I look at their questions and see if it is related to the topic. A few are not serious and are asking nonsense questions. (Lbi3)

This quotation showed how teacher L valued pupils' questions as a way to understand their thinking. Moreover, she described how the pupils interact and follow-up with her answers and were engaged in thinking in the process:

> Others are very strong in learning and their questions show what they are thinking. They have been thinking about it. ... (Apart from the nonsense questions, can you tell the ability of the pupils by their questions?) Yes, the more able pupils will follow-up on the answer that you give them. They will find the answer and re-think. Others will just ask and take the answer as it is. Usually, I will repeat the questions before answering them. Some of the pupils may rethink if my answer is correct. For example, one of the pupils can think in great detail though quite slowly. He asked me why I could hold the iron ruler with my hands while burning

> one end with a candle. He will reconsider if the answer is correct. (He will think if this is the situation, how do you know that he is thinking?) He will ask me again, why is it like this. Others will just stop there, but a few will follow-up on the answer and ask why or they may tell me what they think or their theory. (Lbi3)

In this quotation, the pupils were actively thinking and interacting with teacher L in class. Following on from this reflection, she suggested how it may be difficult to change pupils' conceptions at times when their preconceptions were long established:

> (What do you think about the theory that they built?) There are a lot of daily life experiences, in addition to what they think. They may misunderstand but the theory that they build has a strong impact in their minds. It takes much more effort to change them. (Lbi3)

Finally, she came to the conclusion that this was an effective way of teaching because she knew more about the pupils' learning:

> (You have seen the difference in ability of the pupils, do you like this way of teaching, the way that you encourage them to ask questions, answer questions, ask again, etc?) Yes, this allows interaction with the pupils and I can tell how much the pupils have learnt and the result of my teaching. (Lbi3)

From this analysis, better learning conditions included an increase in the pupils' participation and increased interaction with the pupils. The increased interaction helped the pupils to engage in thinking and also resulted in a better relationship with the pupils. When compared to the differences the beginning teachers noticed in their teaching, they noted significant differences in pupils' learning. When compared to the teaching practice period, the differences were more prominent (Section 6.3.1). The beginning teachers were more aware of promoting the supportive learning conditions and managing the sociocultural environment to facilitate teacher-pupil and pupil-pupil interactions.

8.4.2 The learning outcomes

Unlike the situation during the teaching practice period (Section 6.3.2), the beginning teachers were able to identify a larger number of situations when they found better learning occurring as a result of their science teaching. Two main types of learning outcomes were reported; those concerning the thinking of the pupils and others concerning the increase in the knowledge gain of the pupils. For the improvement in the thinking of the pupils, these were seen from a larger number of questions raised by the pupils, having pupils involved in thinking in the lesson, getting pupils to apply newly learnt concepts, and having pupils develop clearer concepts. Two beginning teachers (B and L) found a larger number of questions raised by their pupils:

> They are more ready to ask questions and when they do not understand, they will ask. Some pupils may daydream if there were no activities. With more activities, they have more questions. (Bbi2)

> They are more ready to ask questions and when they do not understand, they will ask...The pupils have a lot to ask on that point (about how to keep the heart healthy). (Bj3)

> The experiment was to see which material is the best conductor of heat. The pupils raised a lot of questions. (Lj2)

Pupils' questions were stimulated by the practical activities when they did not understand a topic. Teacher E described in the journal that the pupils were involved in thinking in the lesson:

> I asked the pupils to think about what the temperatures were in the different bowls of soup, and the bowls were different sizes.
> This is followed by a practical activity. The pupils were asked to measure the temperatures of the bowls of hot soup using a thermometer.
> I then asked pupils to think why the various bowls of soup were different temperatures.
> Another experiment was to ask the pupils to measure the temperatures of the bowls of cold drink using a thermometer.
> Pupils' response: The pupils can think about the question and find out the answers.
> Questions that pupils ask: Before the experiment, the pupils think that the temperatures in bowls of different sizes are different.
> The pupils asked me to explain the result of the experiment. (Ej2)

In these lessons, the pupils were able to apply their newly learnt ideas or predict the results of a practical activity. Teacher E suggested how the pupils showed an improved ability to think and learn actively:

> However, I feel that the way that they think or the ability to learn by themselves is better than before. (How can you tell?) At

> present, I am forcing them to think it out. Before, it was mostly transmission. Now they have to think, I will tell only when they have problems. (Ebi3)

In the journal, beginning teacher E described how he made use of the activity to stimulate pupils to think and how the pupils could respond to his questions. Teachers B and D reported that the pupils had better learning as they developed clearer concepts:

> They have clearer conceptions about the topic. I learnt this from the way they answered my questions. (Bbi2)
>
> The concept is clearer. For example, the experiment on filtration, using the filter paper shows how the kidney functions very clearly. It becomes very clean and the function is very clear. (Bbi2)
>
> The ones in the pack are special, like those on heat conduction, using butter, the water bottle, etc. These help the pupils to be clearer about the concept. They would know how the thermometer works, when the water is hotter, the column rises etc. They are much clearer and are not just following what the teacher suggests. (Dbi2)

In this way, the topic sequence in the resource pack and the teachers' actions in encouraging pupils to think both contributed to the building up of science concepts in the pupils. Three other beginning teachers (teachers E, I and L) found that the pupils could better respond to their questions:

> (But how can you tell the pupils are learning better?) From the ways they respond to my questions. More pupils raise their hands and know how to answer. With this, the lesson is quite good. (You find that more pupils have raised their hands?) It is better than most of the time. Except that a few were too excited and talked nonsense. Normally, only the bright ones or those above average will raise their hands and get correct answers. In this lesson, quite a number of questions were answered by the weakest pupils in the class. (Really?) The one on the second row and the fat boy: They were correct but most of the time, they can never know what is going on in class. (Ebi3)
>
> I watch the way they answer the questions and their response closely. Most of them can answer the questions, I believe that the pupils have learnt quite effectively. This can be seen from the way they respond to questions. (Ibi3)
>
> See if the pupils can answer the questions in class. (Do you think that your pupils have learnt better in this topic?) It is quite satisfactory to me. They understand how heat is transferred and can tell that iron is the fastest. (Lbi3)

Apart from finding the pupils engaged in thinking in the lessons, the beginning teachers found that there were improvements in terms of the knowledge gained in the subject among the pupils. Two (teachers B and I) described how the pupils had better achievement results in the test or examination:

> (Did the pupils have a test on this topic?) Yes, there was a test. Their result is very satisfactory, only two of them failed in the test. (How about in the past?) In the past, only half of the class passes in the test. This time the paper is easier. However, the pupils have better conceptions this time. (Do you think this is really related to the teaching method that you have employed recently?) I think the teaching has helped the pupils to form deeper impressions and they thus remember better, they don't really need to revise the books. Well, they need to revise, but it has helped them to think quicker, they have formed the impression in the lesson. In using the skeleton, they know which bone is which and thus they can tackle the questions more quickly...They have better memory of the topic. (Bbi2)

> The pupils have a good grasp of the knowledge from what they have drawn (the internal organs in the body) just now. (Bbi3)

For teacher B, the pupils had better achievement results, as the failure rate had decreased. Teacher B attributed this to forming a strong impact on the pupils such that less time is needed for the revision. By considering the learning conditions and outcomes, the findings suggest that by engaging pupils in thinking, getting them to participate, and being interested in the lesson can result in better learning and hence better achievement results in science. Moreover, having an impact on the pupils was also reported by teacher I:

> I believe that they have better learning. (How can you tell?) They will continue to talk about this after a while. Maybe this is new to them. They have not done practical activities in the previous topics. I use only story-telling or pictures and have not done practical activities before. It is their first time. They wouldn't have used candles or fire in primary one. This gives them a deeper impression. (Ibi3)

In summary, the beginning teachers defined the better learning conditions in terms of having pupils more interested in science, participating actively in the lessons, and having a lively learning atmosphere. The beginning teachers valued pupil-pupil interaction in the group work as well as the teacher-pupil interactions. Teacher L related interesting aspects of how the pupils followed up on her answers and raised further questions. She valued the teacher-pupil interactions and described this as an improved condition in learning.

A number of improved learning outcomes were also expressed. The beginning teachers reflected that pupils were better able to answer teachers' questions in class and the teaching method has led to a stronger impact on the pupils. The finding suggests that the concerns about covering the required textbooks and learning for examinations can be addressed. As the beginning teachers attempted to teach science based on a constructivist view of learning, they could cover the equal amount of topics and this teaching could result in better learning which was shown by a decrease in the failure rate.

8.5 Perceived influences after using the resource packs

In order to obtain a picture about the development of the beginning teachers and to find out if the interventions had made an impact on them in terms of their future directions in teaching science, this section describes the changes in the beginning teachers after the implementation of the resource pack. The first part is an analysis of the professional, personal and social aspects of the changes, and the findings presented were obtained from the interviews with the beginning teachers during the period of implementation. The second part describes the changes in the confidence to teach science among the beginning teachers after the implementation of the resource pack. The findings were obtained from two questionnaires (Appendices C2 and C5) administered after the use of the resource pack.

8.5.1 Future directions in science teaching

The beginning teachers were asked in the interview to explain the changes in their science teaching and to look into the future to see what their science teaching would be like. The changes can be grouped into three areas: professional, personal and social. Changes in the professional aspect were further grouped into those concerning the content of teaching, the teaching activities, and the lesson preparation. In talking about the content of teaching, teacher E described how he would consider pupils' preconceptions when he taught the next topic:

> There are suggestions that pupils may have preconceptions in the topic. I will then take note of this as I teach and in other topics, I will also be more aware if there are similar situations. (Ebi2)

For the activities in the science lessons, teacher B proposed how he would increase the inclusion of activities and group work in his science teaching:

> I will try to enrich the content of the activity such that the influence is better. I have really seen that pupils learn better with more resources and through different forms of activities. (For example, how would you improve?) I will try group practical activities and group work. (Bbi3)

Teacher E was aware of the effectiveness of using practical activities and demonstrations; however, the limited time for teaching and the tight teaching schedule may continue to influence his teaching in future:

> I think there may be a change. I may skip the more complicated practical activities. (What is meant by complicated?) For example, those that require a lot of preparation. (Can you give some examples in this topic?) The one using butter and paper clips may be skipped. The preparation is quite difficult. I cannot put the butter on the ruler well beforehand. It melts in just a few minutes. I will consider skipping it if there is a lot of preparation. But I will still consider if the experiment is important for the topic. If it goes with one of the key concepts, I will still do it. If it is not going with a main concept, I may skip it and use pictures to represent it. (Ebi3)
>
> I do feel that doing or demonstrating the practical activities are helpful for pupils' learning. If there is not enough time and the teaching schedule is tight, and I have to cover two topics in one week, then it becomes impossible. (Why is the teaching schedule so tight?) There are a lot of topics in the book and all have to be covered in the term. (The main concern is with keeping up with the schedule?) If time is sufficient, it can be very good. (Ebi3)

In this quotation, the influences of the school, such as setting tight teaching schedules would still continue to influence teacher E's teaching. Teacher I realized the importance of lesson preparation, as she described:

> The teacher has to be very familiar with the topic and the process has to be smooth. Preparation is also very important. I should have tried out the experiment before the lesson just now. I was

> lazy and thought that it should go well. However, there is some difference with the results and I have to try again. The preparation and knowledge on the topic are important. (Ibi3)

Lesson preparation in terms of content and practical activities were seen to be important. Teacher E related the number of activities with the classroom discipline:

> The discipline problem is related to the teaching strategy. If the pupils are obedient and good, I will conduct more activities. If not and the pupils are just doing what they want to do, the number of activities will decrease. (Ebi3)

Teacher L valued the questions raised by her pupils and believed that this is one of the ways to know about pupils' learning. She also thought that her role was to manage the class to let meaningful learning occur:

> I allowed questions but they have to listen to what other pupils are asking about.... Sometimes even I cannot hear the questions if they get too noisy. (This type of teaching method is still good for pupils of different abilities?) Apart from those who are very non-attentive. For most of the pupils, this works. (Which do you think is more important, discipline or allowing pupils to ask questions?) Discipline is more important, if it gets too noisy, they cannot hear well and this becomes meaningless. (Lbi3)

From this, the importance of classroom management is emphasized as a pre-requisite for better learning. Teacher D described how she believed in the use of practical activities to let pupils observe the results. Her emphasis for science teaching was still on getting pupils to remember the content, however, she found the practice of checking pupils' conceptions informative about their learning:

> It is best to have practical activities to prove, the pupils should believe in the practical activities and not the teacher. Something that they can see for themselves is good. (Dbi3)
>
> The most perfect way is to get pupils' resonance. I think worksheets are quite important, if the pupils have done some exercises or circle the answers, they can better remember. It is better than just teacher-talk. (Dbi3)
>
> Using the worksheet on heat production, the teacher may ask the pupils to do this at the beginning or after the teacher has explained the concepts and distribute this at the end to check their learning. I think the latter is quite good and I can check pupils' understanding. It is good after the teaching, I can check pupils' understanding and explain a bit more if they do not. (Dbi3)

Professional development included considering pupils' preconceptions, and using group activities. Moreover, the emphasis on preparing lessons makes the teaching of the beginning teachers very different from other teachers in the school. Apart from other teachers, the tight teaching schedule and classroom discipline may also be taken as sociocultural factors influencing the development of the beginning teachers. In terms of personal changes, the beginning teachers described their confidence to teach science and their feelings about teaching. Teacher E regarded science teaching as a tiring but worthy task:

> I feel a bit tired but the responses from the pupils were better. I think that the effort is worthwhile. (Why is this tiring?) There is a lot to bring into the classroom and it was hard to manage the class again. This is a problem but the pupils were happier. If their academic achievement was better, it would be better. (Ebi3)

Teacher D and E described how their confidence had increased with the support of the resource pack. Their confidence was mainly built on the content knowledge about the topic:

> It would be better if there was more information, then my confidence would be better. Before I teach I will read the information in the book, look at the pictures and think more clearly about them and teach carefully. If there are things that I am not sure of I will avoid them. If the explanation in the book is not clear, I will go through it very briefly. My confidence will be better if there is a resource pack. (Dbi3)

> The preparation is better and I am more confident in (science) teaching. There is information that I do not know or that is not covered in the textbook. By having this, I am more confident. (Ebi2)

> These are helpful and I am more confident. The information has backed me up as I teach. The discussions between the teachers at the same level during lesson preparation are also very helpful. (Ebi3)

Teacher L found herself more confident on the topic heat and would continue to use the resource pack in her teaching next year:

> I have more confidence on this topic. (If you are teaching the same topic again next year, will you use different methods?) I will try to the same set of practical activities. (Lbi3)

Having realized the linkage between the topics, teacher I was more confident; however, her confidence was built only in the topic "heat" and could not be transferred to other science topics:

> The linkage between the topics is clearer and being more confident I can teach better. (Ibi3)
>
> ...It depends on the level and the topic. If I know the topic well, then there is not much problems and I am confident. If I do not know the topic well, I may be a bit nervous and have to prepare a lot on the topic. (Ibi3)

The social development was revealed as the beginning teachers talked about how they would teach another topic in future. Teacher I regarded the support and sharing with other teachers as useful, while teacher B hoped to motivate other teachers in the school to prepare for the science lessons jointly as a team, influencing the culture of the school:

> I will have to ask other teachers. (How will you teach then?) I may follow the way that other teachers have used. The way that they find has worked before. (Ibi3)
>
> (Do you think it is difficult for the teachers?) It depends if the teachers teaching the same level are ready to work together. If there is only me working on this, it will be quite hard. (How do you think your situation will be?) It is quite busy and hard for individual teachers to produce the resources. I have to be a class master, to study and to teach at the same time. (But do you think this is achievable in reality?) If there is pressure, then it can be achieved. If the GS (General Studies) panel chair is determined, then this is also possible. (But the pressure is not really great in school, and then it seems quite difficult to do this.) Yes, most of the teachers do believe that GS (General Studies) is not an important subject. (How is this for you?) I would try to ask other teachers to participate. I don't think it is right to make an interesting subject into a bore. (Bbi3)

The implementation of the resource pack contributed to an increase in confidence among the beginning teachers in teaching the related science topics. The beginning teachers realized the importance of lesson preparation, the use of activities, the consideration of pupils' conceptual development, the encouragement for pupils to ask questions and teaching science with an intention to help pupils to understand, rather than rote learning. These views were consistent with a constructivist view of learning. The beginning teachers' appreciation of the importance of these intentions can partly be attributed to their learning background in the Curriculum Studies module and partly to the implementation of the resource pack. Despite this, their concerns associated with the school context, including those related to pupils' examination scores, the limited time in teaching, and classroom management continued, and further support for these teachers is essential. This also means motivating other teachers to change their views and practices in science teaching such that they also share similar beliefs about science teaching as the beginning teachers. The change in the social or contextual aspects may also support the beginning teachers.

8.5.2 Confidence in teaching science

This section describes the confidence in science teaching among the beginning teachers as shown in the Science Teaching Efficacy Beliefs Measures (Riggs and Enochs, 1990) (see Chapter 3 section 3.3.3). The Science Teaching Efficacy Beliefs questionnaires were sent to the five beginning teachers in the last phase of the study. The Science Teaching Efficacy Beliefs (STEB) instrument measures the Personal Science Teaching Efficacy Beliefs (PSTEB) value and the Science Teaching Outcome Expectancy (STOE) value. Higher values in each or both of them indicates that the respondent is more confident in science teaching. The Personal Science Teaching Efficacy Beliefs and the Science Teaching Outcome Expectancy values (Table 8d) indicate that the beginning teachers were more confident in teaching science.

Table 8d A comparison of the Science Teaching Efficacy Beliefs value in the present study and those obtained in previous studies

	Before taking the module	**After the teaching practice**	**Mean and range of values for the 5 beginning teachers**	**De Laat and Watters (1995) Australia**	**Rigs and Enochs (1990) USA**
PSTE	38.77 (5.18)	42.23 (7.06) **	44.2 (2.0) range 42 to 46	49.6 (range 33-62) S.D. 5.9	56.54
STOE	34.26 (4.02)	39.19 (8.47) **	39.4 (4.93) range 35 to 46	33.9 (range 32-44) S.D. 5.6	48.09

** $p<0.01$ Values in brackets are S.D.

The Personal Science Teaching Efficacy Beliefs and Science Teaching Outcome Expectancy values were higher than the mean value for the whole group of student-teachers before they graduated. Comparing with the mean values from other studies on primary student-teachers in Australia (de Laat and Watters, 1995) and the USA (Riggs and Enochs, 1990), the mean values for Personal Science Teaching Efficacy Beliefs were still lower but those for Science Teaching Outcome Expectancy were higher than the Australian study. This pattern remained unchanged as compared with the teaching practice period.

In the beginning teaching questionnaire (Appendix C5), four out of five of the beginning teachers had equal or more confidence in teaching science topics when compared with other topics in the general studies curriculum (Table 8e). Teacher D had lower confidence in teaching science in GS (General Studies). When science topics were compared with other subjects, all the beginning teachers found their confidence in science teaching at similar or even higher levels. These results suggest that the beginning teachers were confident in their science teaching. Their confidence in teaching science was similar and even higher when compared with that of the two other major subjects in the primary curriculum. Teacher D may have particular difficulties in her science teaching and thus she was less confident in teaching science than in other topics in GS (General Studies).

Table 8e Perception of the beginning teachers in their confidence to teach science

Confidence to teach science	Higher	Same	Lower
Compared with confidence to teach other topics in the General Studies syllabus	Teacher B	Teachers E, I, L	Teacher D
Compared with teaching Chinese	Teachers D, I, L	Teachers B, E	Nil
Compared with teaching Maths	Teachers B, E	Teachers D, I, L	Nil

The beginning teachers were asked to rate their perceived difficulties on a number of science teaching tasks. The mean value for the perceived level of difficulties is summarized in Table 8f and the perceived difficulty for each item for each teacher is shown in Figure 8a. The teachers were asked to rate from a level of 0 to 5 where 0 meant no difficulty. The higher the value of the rating showed a higher level of perceived difficulty. When compared to the teaching practice (Section 6.4.1), the beginning teachers perceived greater difficulty in conducting activities and practical activities in science lessons. They found it less difficult to understand pupils' preconceptions and to stimulate pupils to think. The difficulty with classroom management and with science academic knowledge was comparable with the teaching practice period and was relatively low. The experience in teaching has thus helped the beginning teachers with understanding pupils' preconceptions and stimulating pupils to think in class. However, the beginning teachers had met with constraints from the school and classroom context such that they perceived greater difficulties in conducting activities or practical activities.

When individual teachers were considered, teacher D had a higher level of difficulty in science teaching than when compared with the other four teachers. The rating in conducting activities, practical activities and having sufficient academic knowledge was high at 4, while she perceived no difficulty in classroom management. This may explain her low confidence in teaching science topics. The difficulty in conducting activities and practical activities was related to the school context, as she had related how didactically other teachers taught in the school, and worried about how other teachers might view her teaching.

Table 8f Perceptions of the level of difficulty in conducting various tasks in the teaching of science

Task	**Mean value after the teaching practice**	**Mean value at the beginning teaching phase**
Understanding pupils' preconceptions	2.25 (1.48)*	2.00 (0.82)
Conducting activities	2.40 (1.10)	2.75 (1.50)
Classroom management	2.45 (1.28)	2.50 (0.58)
Having sufficient science academic knowledge	2.50 (1.49)	2.50 (1.29)
Stimulating pupils to think	2.55 (1.23)	2.00 (1.41)
Conducting practical activities	2.60 (1.14)	3.00 (1.41)

* Values in brackets are S.D.

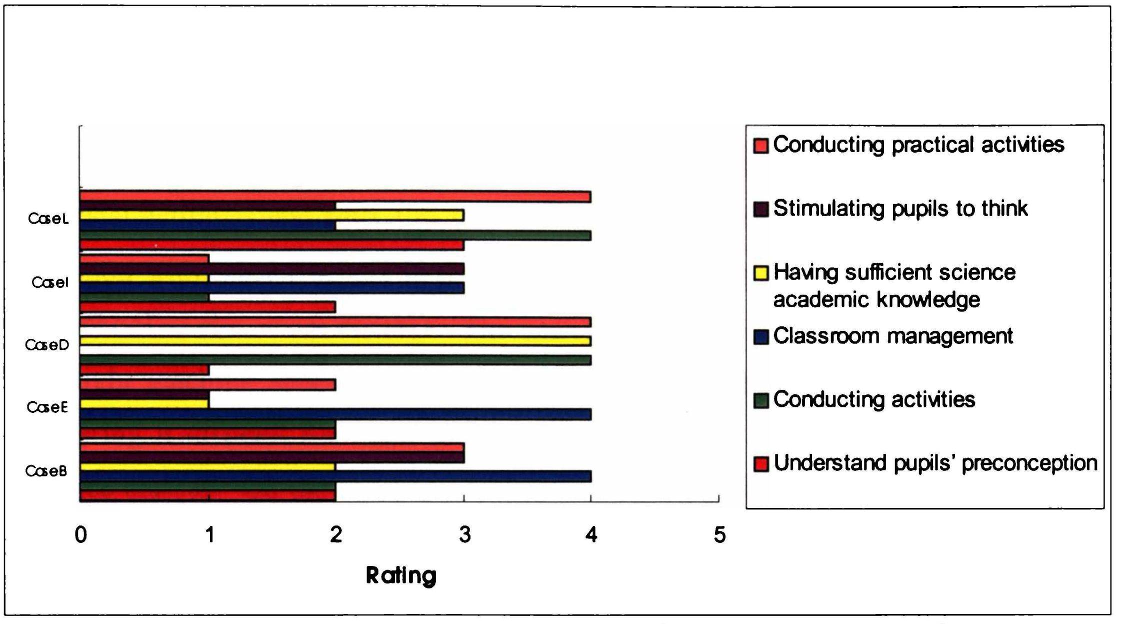

Figure 8a Perceived problems in science teaching for the beginning teachers

Teacher E did not have any particular problems except with classroom management, as he described in the interviews how the school principal expected a quieter classroom. Teacher L perceived greater difficulty with conducting practical activities and activities. This explained why she had teacher-demonstrated practical activities in the lessons instead of group work. She had met challenging questions from the pupils and thus found that at times her academic knowledge might not be sufficient. She also perceived some difficulty in understanding pupils' preconceptions. Teacher I rated all the items at a lower level compared with other beginning teachers. The two relatively higher ones were classroom management and stimulating pupils to think. Teacher B found classroom management a more serious problem and perceived some difficulty in stimulating pupils to think and in conducting practical activities. The difficulty for teachers I and B in stimulating pupils to think may be explained by the condition of interactions between the pupil-teacher and pupil-pupil during the lessons. The level of interaction was relatively lower than for teachers L and E. With the lower level of interaction, teachers I and B were not as certain whether the pupils were engaged in thinking during the lessons, and thus perceived a higher level of difficulty for this item.

It is important to note that the beginning teachers found themselves confident in teaching science as compared with other subjects or topics in the General Studies curriculum. In this way, they would not avoid science topics or feel particularly frustrated when they taught the science topics. The difficulty with conducting practical activities and activities that the beginning teachers perceived may be in common with other teachers in the school, as this arose out of the constraints of the school or classroom context. The heavy workload, the lack of resources, and the tight teaching schedule are common problems faced by the teachers, thus rendering it difficult for them to conduct practical activities or activities in the science classes. On the other hand, this sets the context and a culture for having mostly teacher-talk in the science lessons. The difficulty that the two beginning teachers (B and I) perceived in stimulating pupils to think were related to their classroom situation of getting pupils to interact with each other and with the teacher. The perceived difficulty in classroom management and having insufficient content knowledge also varied with individual situations. The former depended on the expectations of the individual teacher as well as those of the school, while the later depended on the individual teacher and the demand from the pupils.

8.6 Summary

In order to find out if the beginning teachers taught science with a constructivist view of learning and the influence of the support provided by the researcher in the interventions, the researcher looked into the implementation of the resource packs during the beginning teaching phase. The implementation was discussed in terms of the intentions of the beginning teachers, what the lessons were like, the learning conditions and outcomes effected, and the influences of using the resource packs.

During the implementation of the resource packs, the beginning teachers had to consider the tension between teaching science with a constructivist view of learning, their personal confidence, and the sociocultural influence of the school context. As the beginning teachers considered the implementation of the resource packs, there were concerns that arose from their views about teaching and learning, as well as social concerns. There were concerns that came from their views of teaching and learning, and their confidence in running the activities. The concern for the content to be taught means considering whether it matched with the content in the textbook and whether the content was sufficient to cover the examination requirements. This is a very realistic concern in the school context. These concerns about content also reflected the personal views of science teaching among the beginning teachers. For teachers like E and L, they made their choice based on their beliefs on whether the suggestions helped the pupils to achieve better understanding; teacher D made her choice based on whether pupils may score better achievements in examinations, or whether the practice is congruent with those of other teachers in the school. The sociocultural concerns refer to the considerations of how other teachers taught and how they looked at the teaching of the beginning teachers. The beginning teachers did not succeed in motivating other teachers to be involved in the implementation, except for teacher E. Nevertheless, the beginning teachers found the sharing and discussion with other teachers helpful, and improvements for the activities were made. The sociocultural concerns also include those coming from the school and the classroom context. The main considerations in this category were classroom management, the availability of resources, and other school policies e.g. the rule for photocopying of worksheets.

Despite the concerns and the tensions, it appears that the resource packs helped the beginning teachers to teach science with a constructivist view of learning. Moreover, the implementation of the resource pack influenced the beginning teachers' views about pupils' learning. Teacher I reported that the impact on the pupils were deeper due to the lively teaching methods, and teacher D found the lessons less boring compared to those solely dominated by teacher-talk. Teacher E found more changes in terms of pupils' thinking, whereas teacher D observed differences in the knowledge content that was taught, thus showing the differences in these two teachers in their areas of concerns in pupils' learning.

The beginning teachers reflected that the implementation of the resource pack reminded them about the importance of considering pupils' preconceptions and in arranging for a logical sequence that helped conceptual development. This view was consistent with their practice in the classroom. In the lessons observed, the beginning teachers were able to implement strategies that helped pupils in their conceptual development, most of which were suggested in the resource packs. The lessons conducted by teacher L were found to be the most interactive, and teacher E included modifications and detailed planning in his science teaching. Teachers B and I valued pupils' participation and attempted group activities in the lessons though the outcome was not as interactive in the lessons of teachers L and E. Teacher D adhered to a teaching style that was similar to other teachers in the school, with teacher-demonstrated experiments and teacher-talk dominating most of the time in the lesson. From the way these beginning teachers viewed science learning and their practice in the classroom, teachers L and E were found to have a constructivist view of learning that influenced their teaching. Teachers E and D were at the opposite ends of the continuum between a constructivist and a transmission view, while B and I were at the medium of the continuum.

In the lessons when the beginning teachers were using the activities suggested in the resource packs, the beginning teachers realized better learning in the lessons conducted. Better learning conditions included increased participation and interest among the pupils. Better learning outcomes included improved test results, more questions raised, having pupils who responded to teachers' answers, and having better responses from the pupils. The interactions between the pupils and between the teacher and the pupils were found to be important in both engaging pupils in thinking and in finding out if pupils understood the topic.

During the beginning teaching phase with the support of the interventions in the study, a number of teacher developments can be identified among the beginning teachers as a group. Professionally, the beginning teachers noticed the importance of engaging pupils in thinking and in arranging the topic in such a way that it supported pupils' conceptual development. Further, the concern for the content knowledge varied with the individuals and with the demands from the pupils. Personally, they felt themselves more confident in teaching science as compared to the phase before their graduation, and were equally or more confident in teaching science as with other subjects in the primary curriculum. Socially, they hoped to motivate other teachers in the school to have better preparation for the science lessons. However, the contextual constraints such as the lack of resources, classroom management and a tight teaching schedule will continue to influence their teaching. These may render the implementation of science activities and practical activities difficult.

Chapter 9

Theorizing about teacher development

In this chapter, the development of the participants of the study in the teacher education programme and the beginning teaching phase is to be related to the interventions. Furthermore, the process of teacher development is theorized in terms of a sociocultural activity and as a process of teacher socialization.

9.1 Describing the development of the student-teachers/ beginning teachers in the process of learning to teach science at primary level

The data analysis tends to suggest that the interventions in the teacher education programme and at the beginning teaching phases had facilitated the development of the student-teachers or the beginning teachers. In this section the development of the student-teachers and the beginning teachers are summarized in terms of the following aspects: professional, personal and social developments.

9.1.1 Summarizing the professional development

The professional development of the teachers refers to not only the change in the use of the teaching activities or the adoption of the teaching strategies but also the change in the beliefs and conceptions about science teaching. In the study, the participants were seen to have undergone professional development if they taught science based on a constructivist view of learning. The professional development of the participants can be seen to include three main areas: the changes in the teacher actions in science teaching; the changes in the teachers' intentions or views of science teaching, and the changes in the views about science learning of the pupils. While the first two areas can be summarized at the student-teaching phase, the views about pupils' science learning became apparent only after the beginning teaching phase had commenced.

With regard to the teacher actions, a list of nine teacher actions were reported in the literature review (Chapter 2, section 2.3.1). These are actions that help the conceptual development of pupils, and the list was drawn up to analyse the teaching of the student-teachers. These actions made the science teaching experience among the student-teachers different from those in the first year of the teaching practice. All the teacher actions were performed in the teaching practice period, though there were individual variations in the degree of implementation (Section 6.2.3.1). With the exception of two of the lessons observed, the other nine student-teachers were able to implement five or more out of the nine teacher actions. At the beginning teaching phase, the implementation was generally high among four of the five teachers (Section 8.3.2). Four of the five beginning teachers were able to implement four or more of the teacher actions in the lessons observed. This is consistent with the findings about teachers' intentions or their views of science teaching. The participants started with a view of science teaching as equivalent to conducting practical activities and teaching science content knowledge (Section 4.3). At the end of the Curriculum Studies module, they held a more diversified view about science teaching. The intentions behind science teaching were not only equated to the teaching of content knowledge but also to engaging pupils in thinking, enhancing pupils' interest in science and preparing pupils for continuous learning (Section 5.4.2.1). During the teaching practice, pupils' preconceptions were considered as important as the student-teachers adjusted their teaching according to what the pupils knew (Section 6.2.2). They were ready to re-arrange the topic sequence and be flexible in the timing of the teaching schedule (Section 6.2.1). Moreover, the teaching content was not limited to those covered in the textbook (Section 6.2.3.1 iv, ix). Understanding the purpose behind the actions, and believing that the purpose of the actions is worth pursuing, was important (Section 5.3). This made the implementation of the teaching actions more meaningful. It may be assumed that the teacher education programme resulted in not only changes in the teaching actions of the student-teachers (Section 6.2.3.1) but in ways that they viewed science teaching (Section 5.4) and learning (Section 5.3). After the teaching practice phase, their views of science teaching shifted to include a number of contextual concerns that arose from the school or classroom context, such as conducting practical activities, considering pupils' abilities and providing opportunities to let pupils learn from each other (Section 6.4). These concerns during the teaching practice, may suggest that the student-teachers began to feel the tension between the influence of the Curriculum Studies module for teaching science with a constructivist view of learning and the sociocultural influences from the school and classroom context.

Consistent with a constructivist view of learning, the beginning teachers were concerned about pupils' preconceptions, how to arrange the topics in a logical sequence, and in engaging pupils in thinking in the lessons (Section 7.3.3). In addition, they were also concerned about pupils' achievement in tests and examinations and were influenced by the school culture (Section 7.3.4). The practice of drilling pupils' writing, the norm of having little preparation for lessons, and the way that other teachers regard their teaching all influenced their views and practice of science teaching (Section 7.3.4). The influences from the school worked in an opposite direction to that of the Curriculum Studies module and tended to make them adhere more to the textbook and to give up group discussion (Section 7.3.2). Nevertheless, the beginning teachers were aware of the implications of the constructivist view of learning on their science teaching in their minds.

The view of science learning among the participants underwent changes in the process. The student-teachers started by defining science learning as mainly the learning of the basic concepts and knowledge (Section 4.2). After taking the Curriculum Studies module, they were aware of the different aspects of science learning as in developing an interest, an attitude for thinking or self-learning and an ability to build up concepts (Section 5.3). Although the practice of the student-teachers was different from that in their teaching practice in year one (Section 6.2.3.1), only a few of them could identify better learning among their pupils (Section 6.3). Hence, the teaching practice in year two had resulted in different teacher actions but better learning among pupils was not obvious. The scenario was different after they implemented the resource packs in their first year of teaching. The beginning teachers related better learning conditions such as gaining pupils' participation and responses, questions and interactions in the science classes (Section 8.4.1). Further, they identified better learning outcomes as having better achievement results in tests, forming deeper impressions of learning, getting better questions and responses from the pupils, and having pupils who responded to or followed-up on the teachers' answers (Section 8.4.2). The teachers observed the pupils' thinking and understanding from the way the pupils interacted with the teacher and with their peers. These became learning outcomes that the beginning teachers targeted in their teaching. It appears that the support provided in the present study, including the resource packs, the workshop and the telephone inquiries facilitated the development of the beginning teachers such that they could teach science based on a constructivist view of learning, as well as detecting better learning conditions and outcomes among their pupils.

Although there were changes in the teacher actions as well as in the views of teaching and learning of the novice teachers in the present study, it is acknowledged that the development in the Hong Kong context is of a different nature from that found in a science classroom when there are already a lot of interactions between the teachers and the pupils, as found in other countries such as New Zealand (Bell and Gilbert, 1996).

9.1.2 Summarizing the personal development

Personal development involves individuals and the feelings associated with the change process (Bell and Gilbert, 1996). The data analysis tends to suggest that the interventions in the present study facilitated the personal development of the student-teachers or the beginning teachers. The student-teachers had started with images of failures of their own science learning experiences in their previous education (Section 4.4.2). They expressed much worry and anxiety over teaching science (Section 4.5). An increase in the confidence of the participants was identified after the Curriculum Studies module (Section 5.5), and even more significantly after the teaching practice (Section 6.5.2) and after the implementation of the resource pack (Section 8.5.1). The quantitative Science Teaching Efficacy Beliefs measures provided support to the qualitative results about the gains in confidence among the novice teachers (Section 6.5.1; Section 8.5.2). After studying the Curriculum Studies module, the student-teachers related feelings like being confident about teaching science with knowledge of pupils' preconceptions, finding the work worth the effort, and feeling that it was interesting to understand how pupils think (Section 5.5). After the teaching practice, a majority of the student-teachers in the study reported on the ways that they taught science by taking into consideration pupils' preconceptions, rearranging the topics in a logical sequence, and making the teaching more pupil-centered (Section 6.2.2). These practices or the knowledge of these contributed to an increase in their overall confidence to teach science. The feelings of fear and worry at the beginning of the study turned into more contextual concerns about implementing the practices that promote pupils' thinking (Section 5.5). On the whole, growth in their level of confidence can mainly be attributed to their experience of being able to stimulate pupils to think in the lessons, knowing about planning science lessons, having the knowledge about conceptual development as a basis for arranging the content, and having actually taught science that resulted in better learning conditions and learning outcomes.

Regardless of the increase in the personal confidence in science teaching, the beginning teachers expressed that their future directions in science teaching would be highly influenced by the sociocultural environment in the school. The norm among other teachers of having few activities in the lessons, the emphasis on scores in examinations, and the views that other teachers had about the teaching of the beginning teachers constitute the sociocultural influences of the school (Section 7.3.4). Therefore, having the knowledge, experience and confidence in teaching science based on a constructivist view of learning, are not sufficient to indicate that these teachers will continue to teach with an aim to take into account pupils' thinking. These personal beliefs in science teaching came to interact with the sociocultural influences in the school and the latter may become determining factors.

9.1.3 Summarizing the social development

Social development involves the development of interactions with others that influence the reconstruction of the meaning of being a science teacher (Bell and Gilbert, 1996). It appears from the data analysis that the interventions in the present study facilitated the social development of the student-teachers and the beginning teachers. From their previous educational experiences, the student-teachers shared a view that the science teacher has to conduct practical activities in class and teach the science content (Section 4.3). The Curriculum Studies module facilitated changes in the views about the meanings of being a science teacher. In the module, the student-teachers were encouraged to talk about teaching and learning science with their peers. The discussions and the hands-on experiences in the module helped the student-teachers to draw parallels between their own learning experiences and those of their pupils (Section 5.2.2). In addition, each individual student-teacher compared their own views with those of their peers and the researcher during the interactions (Section 5.2.1). The importance of interaction in their learning was later transferred to their teaching in the primary classroom. The meaning of a science teacher was seen to include interacting with the pupils in the science classes.

During the teaching practice, the peers and the supervising lecturers played an important role, as most of the student-teachers reported that their discussions were useful in their lesson preparations (Section 6.2.1). Moreover, they also started to feel the tension of the sociocultural influences in the school context such as pupils' ability and the constraints regarding conducting practical activities in the classroom. These may have posed difficulties for the student-teachers as they attempted to teach science based on a constructivist view of learning.

The social development of the beginning teachers refers to how they viewed themselves as teachers in the school context or in relation with other teachers. The beginning teachers found themselves different from other teachers in that they were more ready to conduct activities and placed a greater emphasis on understanding, thinking and participation (Section 7.3.3). The norm in the school was quite the contrary with teachers emphasizing drilling pupils' writing, following the textbook in their teaching and taking a transmission approach to teaching (Section 7.3.4). The beginning teachers were conscious of the expectation of the school in aiming for better achievement and better classroom control. In addition, they faced the constraints of lack of resources, time and classroom management problems. Despite the difficulties and differences to the norm, the beginning teachers persisted in engaging pupils in their thinking in the lessons (Section 7.4.2). The meaning of being a science teacher was thus derived with a struggle between the norm in the school and the teacher's own persistence about teaching science based on a constructivist view of learning. Another meaning of being a science teacher was to interact with the pupils and to get them thinking in the lessons. One of the beginning teachers succeeded in getting the pupils to be responsive in the lessons and to think actively. Another beginning teacher E motivated other teachers in the schools to try out the activities in the resource pack and had them discussing science teaching (Section 8.2.3). In this case, being a science teacher in the school also therefore carries a meaning of motivating or helping other teachers with their teaching.

9.2 Learning to teach as a sociocultural activity

From the findings of the study, the novice teachers underwent professional, personal and social development in the process of learning to teach. The learning process for the student-teachers and the beginning teachers can be explained using a sociocultural view, based on the observation that the process is largely influenced by the teacher education institute or school culture and shaped by contextual factors at work in different phases of the study.

The influence of the school culture was seen as the student-teachers first started to test out what they had learnt in the Curriculum Studies module in the teaching practice. Their concerns in science teaching shifted from concerns mainly about their own teaching, to include concerns about pupils' learning. However, pupils' learning ability and responses are regarded as contextual as this varies under different classroom situations (Section 5.5). At the beginning teaching stage, the influence of the school context became more evident (Section 7.3.4). This can be enhancing when other teachers were engaged with similar concerns as the beginning teacher, as in the case of teacher E. The teachers in the school shared their teaching resources and discussed their teaching strategies. The beginning teacher E became more confident in his beliefs about science teaching and motivated other teachers to employ more activities in their lessons (Section 8.2.3). The school culture was enhancing his teaching as other teachers worked together to improve the lessons and did detailed planning of the implementation. At the same time, the beginning teacher found that what was learnt in the Curriculum Studies module and the materials in the resource pack could be well placed in his classroom situation.

The school culture could act otherwise. For other teachers in the study (B, I, L and D), there was little exchange between the teachers about science teaching. Like other teachers, the beginning teachers shared similar concerns. For example, regarding pupils' achievement in examinations, although there was a varying degree of concern among the beginning teachers in the study (Section 7.3.4). The use of the materials in the resource pack had to be matched with the textbook or the school context, such that the concerns for achievement, the coverage of the content and how other teachers thought about their teaching were addressed (Section 8.2.1; Section 8.2.2).

While the school can be taken as a wider cultural context, the classroom or the group of pupils made up a smaller cultural context. The expectations of the pupils and the ways they responded to the science teaching method shaped how the beginning teachers taught, and vice versa. Teacher L succeeded in getting the pupils to think in the science lessons, to respond to her questions and to raise further questions after hearing her answers (Section 8.3.3.3). This was not common among the other teachers and this particular way of involving the pupils in thinking had to be developed over time. The interactions between the teacher and the pupils shaped each other's activities, responses and further actions.

As to how pupils responded to the teachers' answers, various forms of social interactions were important in influencing the learning and teaching processes in the study. The student-teachers first mentioned this in the interviews after taking the module (Section 5.2.2). They reflected on their learning experience as on how their views about science teaching were important and drew comparisons between their learning experiences and of the pupils. The student-teachers experienced how the exchanges and interactions between learners facilitated the learning process. Having had that experience, they developed stronger values about having pupils' interactions in their own teaching (Section 6.3.1). On the whole, the social interactions that facilitated the learning of the student-teachers included those between the teacher educator and the student-teachers, as well as those among the student-teachers themselves. In the classrooms, the social interactions include those between the teacher and the pupils and those among the pupils themselves. The novice teachers saw the activities and the practical activities conducted in the lessons as stimulations to get pupils thinking and talking about science.

The social interaction in the wider school context refers to those between the teachers. The influence of this was seen in the case of teacher E as described above. Moreover, as a result of the exchange or interactions between the teachers, the practice of science teaching by the teachers as a group evolved to include new strategies. The teaching of the individual teacher E was also influenced as a result of their interactions (Section 8.2.3).

Having described the school culture and social interactions are significant influences on the learning process of the novice teachers, the next section discusses the process of learning to teach as a sociocultural activity. The process is facilitated by purposeful actions, mediated actions and mediational means in which language is an important mediational means. The later part of the section considers the mediated actions, language as tools that help novice teachers to learn, and a tool kit approach.

9.2.1 Learning to teach through mediated actions

A sociocultural view of learning regards thinking and learning as mediated actions (Wertsch, 1991). Mediated actions involve the employment of mediational means like technical tools or instruments that help learning or the human activity. The person applying or using the mediational means is referred to as the agent. Both mediational actions and mediational means carry the purpose of socializing an individual into a culture. The interaction between the agent and the mediational means create new functions and influences. In the process of the activity, a close relationship between the individual's psychological process and the sociocultural setting is made. With the professional, personal and social development reported in the study, it appears that these mediated actions and mediational means employed in the present study facilitated the development of the student-teachers and the beginning teachers.

The various strategies employed by the teacher educator in helping the student-teachers or the beginning teachers in science teaching can be viewed as mediated actions. In this case, the student-teachers came with previous images about science teaching from their past educational experiences (Section 4.4). The Curriculum Studies module is a link between the institutional culture and the previous ideas of the student-teachers, which came from the school culture. The mediated actions included the activities, discussions and interactions in the Curriculum Studies module (Section 3.5.1). The resource pack introduced during the beginning teaching phase can be regarded as a mediational means (Section 7.6.1). Moreover, the opportunities for experience sharing, providing feedback and discussions as well as the stimulation for reflection were mediated actions conducted by the teacher educator (Section 7.6.2; Section 7.6.3; Section 7.6.4). By taking teacher education practices as mediated actions, the teacher educator or the agent has to be clear about the goal or purpose, or intent of an action. This understanding or awareness about the intent is also seen to be an important part of the pedagogical content knowledge for teacher educators as suggested by Loughran (1997). In the present study, the mediated actions were goal directed, that is, introducing the student-teachers to a constructivist view of learning, the various approaches in science teaching, and helping them to increase their confidence in science teaching. The teacher educator's task was to mediate the students learning of teaching science based on a constructivist view of learning.

Similarly, the teaching strategies of the student-teachers or the beginning teachers in their science classrooms can both be considered as mediated actions. The activities, practical activities and the discussions that they used in the science classrooms are actions to mediate their pupils into the scientifically literate culture. These actions came with goals, such as engaging pupils in thinking in the lessons and were shaped by the intentions and beliefs of the teachers. The minds of the individual pupils and the mind set of the pupils as a group were influenced in the process. As Tobin (1998) described, "The role of the teacher in assisting students to develop canonical understandings of science is to mediate between two communities, namely, a classroom which is gradually evolving to become more science-like over time, and the community of science." In the study, the beginning teachers attempted to mediate the pupils' learning and to enculturate them into the community of scientifically literate people by actively engaging them in thinking through the activities and the discussions. The teacher actions or the mediated actions included the strategies that they employed during their lesson planning stage and the strategies for helping conceptual change during the science lessons. The strategies that the student-teachers or the beginning teachers employed were consistent with a constructivist view of learning and they also found better learning by their pupils.

9.2.2 The importance of language in learning

While mediated actions are regarded as a linkage between the cultural context and the individual mind, interactions between individuals through language is seen as one of the important mediational tools. Wertsch (1991) emphasized that human action employs "mediational means" that include tools and signs. Language is regarded as a sign. The transmission of information involves the change of the ideas in the mind of the sender into signals. Language provides a link between the sender and the receiver, thus language also shapes speaking and thinking. Moreover, Wertsch (1991) argued for a relationship between language and thinking while acting indicated a link between psychological process or the mind of an individual and the sociocultural setting. According to Wertsch (1991), language functions as a mediator between the intramental and intermental planes and enables the learner to examine the intermental plane through the dialogic process. It is the interaction between the individual and the social context that gives rise to higher order thinking. This means social interactions occur before higher order thinking. In the present study, the importance of language in shaping thinking was seen from both the learning process of the student-teachers or beginning teachers as well as the primary pupils in the science classes. Moreover, the importance of interactions and communications in enhancing the professional development of student-teachers is also supported by teacher educators (Northfield and Gunstone, 1997).

In the process of learning to teach in the Curriculum Studies module, the researcher was trying to socialize the student-teachers into a culture of teaching science that aims to engage pupils in thinking, and to familiarize them with the implications of science teaching based on a constructivist view of learning. The mediational means or tools included the language or the discussions that were held in the module sessions. During the learning process among the student-teachers, their discussions functioned as a mediated action between what they think in their own minds (intramental plane) and what other learners think (intermental plane). In the Curriculum Studies module when the student teachers discussed science teaching, they supported and interacted with each other in their learning through the discussions about the advantages of teaching science based on a constructivist view of learning with both the lecturer and their fellow classmates after the activities (Section 5.2.1). The power of persuasion comes both from the researcher and the peers as their thoughts about science teaching were shared in the process of discussion. These experiences finally led to a situation where in the student-teachers were comparing their learning experiences in the module with the learning processes of their pupils in the classroom (Section 5.2.2). Having experienced the use of discussions in influencing their views of science teaching, some of the student-teachers developed the intention of engaging pupils in discussions, so as to get the pupils thinking in the science lessons. Language, talking about science and science learning becomes an important linkage between the individual's mind and the social context of science or science teaching. Language is used when the learners interact with each other as well as when the learners interact with the teacher. Language, therefore facilitates the learning process and the thinking of the learners.

On the other hand, language or discussion play an important role in influencing the thinking or getting pupils to engage in thinking in the science classroom. As the teacher is trying to socialize the pupils into the science classroom, the interactions between the teacher and the pupils help the pupils to develop a way of responding to the teachers' questions and speech. In the process, the interactions in the science lessons included answering the teacher's questions, asking relevant questions, considering the teacher's responses, and raising follow-up questions (Section 8.3.3.3). This type of interaction and use of language guides the thinking of the pupils. The development of these interactions in the classroom and this habit of being engaged in thinking continuously in the science lessons took time to develop and, more importantly, the teacher had to have the intention of using questions as one of the mediated means to stimulate pupils to think in the lessons. In the study, teacher L succeeded in doing so while the others teachers E, B and I were attempting to achieve this (Section 8.3.3.3). However, teacher D did not have the intention of stimulating pupils' active learning and high order thinking, and thus the lessons were dominated by teacher-talk (Section 8.3.3.5).

Wertsch (1991) noted that as language is seen as a sign or code that mediates individual minds within the sociocultural setting, a process of coding and decoding is involved between the sender and the receiver. The sender transmits the information or ideas into signals or language, while the receiver has to decode the signals before these become meaningful messages. In the first part of the process, the coding involves a decontextualization of the information, and the second part of the process is a recontextualisation of the message. The recontextualisation can be problematic if the receiver finds that the message does not have much relevance to "local settings". Under such circumstances, either the settings have to be reshaped or the actions have to be modified or reinterpreted.

The process of decontextualisation or coding, and recontextualisation or decoding occurs with the learning of the student-teachers or the beginning teachers. In the design of the Curriculum Studies module and the resource packs served as mediational means that helped the student teachers to learn to teach. The content and the rationale behind these mediational means were shaped by the influence of the researcher, which can be described as the institutional culture of the teacher education institute. For the student teachers, the module or the resource packs were decontextualised and the principles of their design were abstracted. These messages had to be recontextualised and reinterpreted as they started their teaching in the teaching practice and beginning teaching. During the teaching practice, as the student-teachers were teaching in the school for a very short period of time, i.e. for eight weeks, the influence of the school context was minimal compared to that on a full-time teacher. The recontextualization did not turn out to be difficult, and the major influence on their teaching was still the institutional culture. However, the scenario was different as the beginning teaching phase commenced. The influence of the school context was strong, and also the recontextualization was difficult as the values and beliefs of other science teachers focused on examination achievements instead of engaging pupils in thinking. Teacher D chose to teach with a transmission approach in her science teaching as other teachers did in the school, and the contents in the resource pack did not make much meaning or value in her teaching compared to the other beginning teachers (Section 8.3.3.5). The other beginning teachers tried to come to a compromise between the school culture and their beliefs about science teaching (Section 8.2.1; Section 8.2.2). These teachers still held strongly to their views of engaging pupils in their thinking in science lessons (Section 7.3.3). These teachers implemented the resource packs in a way that catered for both the concern of the school and their belief in engaging pupils in thinking (Section 8.2.2). The recontextualization included a comparison of the textbook contents and the suggestions in the resource packs, making a choice over the topic sequence suggested, the use of the worksheets and the adoption of the activities included in the resource pack. The suggestions and the learnings in the Curriculum Studies module were reinterpreted and placed into the school or classroom context of the individual teachers.

9.2.3 The tool kit approach

The previous section have described firstly the Curriculum Studies module and the resource packs as mediated actions of the researcher/ teacher educator in socializing the student-teachers into the community of science teaching. Secondly, language was seen as a linkage between the mind and the sociocultural context, which also leads to high order thinking. Both the contents in the Curriculum Studies module, together with the resource packs and the language, is considered to be an important mediational means for the researcher in helping student-teachers to teach. The notion of a tool kit approach that includes a variety of mediational tools was proposed by Wertsch (1991),"In this connection I would suggest that mediational means can be viewed not as some kind of single, undifferentiated whole but rather, in terms of the diverse items that make up a tool kit."(Wertsch, 1991, p.93). He maintained that people have access and the choice to choose from a range of mediational means for particular occasions or purposes.

The notion of the tool kit was first used to explain cognition, but was later developed to explain mediational means. According to Wertsch (1991), Vygotsky wrote that different levels of thinking coexist in a person or child's mind. As the individual comes to learn new concepts or attain higher orders of thinking, the old or primitive forms remained. The lower or primitive forms and the higher or new forms coexist, lying on top of each other like the earth's core deposit layers.

Under different circumstances, the person may choose to function at the lower or higher levels. Though Vygotsky did not explain why a person might choose to function at a lower level, the tool kit approach was further elaborated by other theorists. There were views that the tools were chosen according to the functions of the sphere of life or according to the forms of the activity (Tulviste, 1986). Moreover, the tools could be regarded as forming a continuum from more primitive to advanced forms, or that the tools were acquired according to developmental stages (Tulviste, 1986; cited in Wertsch, 1991). There were also views that the tools are not ranked in any order of genesis but just emerge independently (Gilligan 1982).

The teaching of the teacher educator can be viewed as adopting a tool kit in which the different tools are designed for different purposes, instead of being arranged from primitive to advanced tools. This tool kit includes mediational means that aimed to change the conceptions of student-teachers or beginning teachers in their science teaching. As discussed in the previous sections, the mediational means included the actions of the researcher in the Curriculum Studies module (Section 3.5.1), the language, and the resource pack during the last phase (Section 7.6). The use of the tools was decided upon according to the purpose of the actions and the perceived needs of the learners. In this case, the student-teachers started with experiences of learning science from the transmission and discovery approaches. The researcher therefore decided to provide them with experiences of learning science when science is taught based on a constructivist view of learning. In the last phase of the study, the perceived needs of the beginning teachers were identified and these findings informed the design of the resource pack. The resource pack as a mediational means was later developed based on the needs of the beginning teachers.

The process of helping novice teachers to teach science could be drawn parallel with helping pupils to learn science in the classroom. In both of the teaching situations, the teacher has to diagnose the needs of the learner and plan for further action. Teaching is considered to be a choice of mediational means from a tool kit. The adoption of a particular means depends on the perceived needs and interests of the learners. The novice teachers had to mediate between common sense or pupils' preconceptions and science concepts. The teacher educator had to mediate between science teaching that stimulated pupils to think, and the previous conceptions of the student-teachers about science teaching. In both of the processes, language played an important role in shaping the thinking of the learners. Through teacher-learner and learner-learner interactions, the learner compares their thoughts at the intermental and the intramental planes. In the study, both the researcher and the participating teachers had more understanding about their learners, and based on this understanding, designed various and appropriate mediational means, which may be interpreted as a tool kit.

Similarly, the tool kit approach can be applied to understand the teaching actions of the beginning teachers in their school context. The student-teachers came to the Curriculum Studies module with their own understandings and experiences about science teaching and learning. These can be regarded as earlier acquired tools, which largely consisted of strategies related to the transmission and the discovery approach. In the Curriculum Studies module, they realized that they might implement different teaching strategies as suggested in the discovery or process approach, while keeping in mind about teaching science based on a constructivist view of learning. The various types of strategies become the mediational means or tools in the tool kit of the student-teachers and these are not arranged in an order from primitive to advanced. When it came to the implementation in the classroom during the teaching practice or the beginning teaching phase, the novice teachers then had to choose from their tool kit, which particular strategy or mediational means to adopt. They make their choice based on their intention and purpose. This may explain why not all the beginning teachers chose to adopt the advocated science teaching strategies based on a constructivist view of learning. The findings suggest that the novices were aware of the importance of getting pupils to think in the science classes, but due to various contextual constraints they were not willing to implement the teaching strategies advocated. The novice teachers adopted different teaching strategies as they considered the influence from the school context as seen in the contrasting strategies adopted by D (Section 8.3.3.5), E (Section 8.3.3.4) and L (Section 8.3.3.3). Teachers (L and E) who held stronger beliefs about science teaching as engaging pupils in thinking, chose strategies that were consistent with a constructivist view of learning. The purpose behind the actions was to get pupils asking and answering questions and making them think in the classes. Teacher D, who found the contextual influence stronger, and who did not hold strong beliefs about engaging pupils in thinking, chose to adopt the transmission approach. The purpose behind the action was to get pupils to score higher marks in tests or examinations, which emphasized the assessment of pupils' recall of the content. Other individuals (teacher B, Section 8.3.3.1 and teacher I, Section 8.3.3.2) showed an intention to adopt teaching strategies based on a constructivist view of learning, but the classroom experience was not as successful. It thus remained to be seen whether their personal beliefs in science teaching for understanding or that the contextual influence for rote learning were stronger. For the time being, it is possible that their teaching may transcend the different strategies or mediational means depending on the purpose they had on a particular occasion.

Teaching itself is also a learning process in which the teacher realizes the needs of the learners and adjusts the teaching method or chooses the appropriate mediational means. The decision to adopt a teaching strategy as described above, is a dynamic process. Tobin (1998) argued that the teacher diagnoses the teaching process and frames the roles based on perception of needs and interests among the pupils. It is, therefore, possible that the novice teachers will change from adopting one strategy to another mediational means from a tool kit based on their perception of the needs and interests of the pupils. Teachers I and D related, after the implementation of the resource packs, that the pupils were reluctant to switch back to the previous way of having science lessons as dominated by teacher-talk (Section 8.2.4). Based on the perceived needs of their pupils, they may adopt a more interactive strategy in future. Furthermore, teacher L found her pupils responding well to interactions in the science lessons and this thus reinforced her choice of continuing with the same strategy in her teaching. The resource packs helped the beginning teachers to see how learning among pupils may be different. Subsequently, the beginning teachers may come up with different ideas and considerations about science teaching. The importance of the resource packs was to provide the beginning teachers with a different experience about science teaching and seeing better learning among their pupils. These experiences may lead to changes or re-inforcement in their beliefs about science teaching. Therefore, the beginning teachers may adopt strategies that are based on a constructivist view of learning.

Having described learning to teach in terms of mediational actions, language and a tool kit approach, the following section considers the process of learning to teach by focusing on the interactions between the learner and the context with a holistic view.

9.3 Describing teacher development using three planes of analysis – apprenticeship, guided participation and participatory appropriation

A participatory appropriation model is described by Rogoff (1995) and was described in Chapter 2 (Section 2.2.2) as being a dynamic model in which the participants change and influence each other in the process. While the studies in teacher socialization analyse the beginning teaching phase as the results of power imbalance between the individual teacher and the school (Liston and Zeichner, 1991), the sociocultural view offers a view of learning as involving mediated actions and cultural tools or mediational means. Taking the influence of mediated actions and mediationl means together, Rogoff (1995) suggested the value of analysing sociocultural activities in three planes: the community plane or the apprenticeship plane of analysis, the interpersonal plane or the guided participation plane of analysis, and the personal plane or the participatory appropriation plane of analysis. The purpose of these planes of analysis is to explain how individuals develop participation in cultural activities with an increasing degree of involvement as the plane of analysis moves from apprenticeship, to guided participation to participatory appropriation. In the present study, the learning process of the student-teachers can be analysed as a socialization experience that can be viewed from each of these three planes of analysis.

The purpose of the apprenticeship plane is to understand the development of how novice individuals develop to become mature participants in a social activity. In this case, the use of the term "apprenticeship" is to understand how novice teachers develop under the influence of prior educational experiences as well as the Curriculum Studies module in the teacher education programme. Before the programme, the student-teachers had images of science lessons and experiences of science learning from their own past education as pupils. The observations of the teaching of their science teachers influenced their views about science learning and teaching. The early experiences of science learning can be taken as the first socialization experience of the student-teachers into the teaching profession. The thirteen years of education involved can be seen as observations of science teaching such that these become an apprenticeship experience. Rogoff (1995) related the apprenticeship relationship in socialization from a community plane with the help of experts. The novices and the expert may work on a one-to-one basis or may also work on in a small group under the help of the expert. Peers play an important role as resources for each other and challenges to each other in their learning. As the student-teachers came to the Curriculum Studies module, they were socialized into science teaching based on a constructivist view of learning with the help of the teacher educator as an expert. The interactions between the student-teacher and the teacher educator as well as those between the student-teachers themselves may both facilitate the learning. Moreover, in order to make these interactions meaningful and achieve the aim of facilitating the development of the student-teachers, there needs to be a trusting relationship between the learners and the expert or the teacher educator. The importance of this trusting relationship was emphasized in the teacher education literature (Loughran, 1997).

The interpersonal plane of analysis called guided participation (Rogoff, 1995) highlights the importance of joint participation and side by side guidance from a more experienced person. This plane is further developed from an earlier notion of guided participation that was applied to explain the learning of young children (Rogoff, 1991). However, the principles of the process are maintained. This plane of analysis emphasizes the mutual involvement of the participants as partners who communicate, collaborate with each other and hence share cultural and social values. The purpose of the guidance is to provide a linkage between familiar knowledge and new situations or problems. The more experienced person needs to arrange and structure the problem, then gradually encourage the learner to take up a greater responsibility. This may be used to explain the development of the beginning teachers as they work alongside the teacher educator in the beginning teaching phase. In a similar vein, Clarke (1997) described the advisor at a field practicum as a coach who works with the novice teacher, provides resources, acts as a stimulator for alternative ideas and helps the novices to find out new strategies. Throughout the process, a number of interactions between the two are involved. Within the guided participation plane, the participants in the present study were the beginning teachers and the teacher educator who were actively involved in constructing the meaning of teaching science in school together through their interactions. The teacher educator was able to help the beginning teachers to build up their understanding about teaching science in schools as beginning teachers. The purpose was to provide a linkage between the knowledge of teaching science based on a constructivist view of learning and the authentic classroom situation and problems that the beginning teachers were facing. The teacher educator worked along side the beginning teachers by observing their teaching, and discussing their concerns with them. Having found out the needs of the beginning teachers, the teacher educator provided further guidance through the resource packs and other forms of support. In summary, guided participation is compared to the learning of the beginning teachers; the active learners were the beginning teachers; the link with the culture was the social support and resource packs; the problem was to teach science in a primary school. In addition, the guidance was provided by the teacher educator, who interacted closely interactions with the beginning teachers and constantly fine tuned the support based on their needs.

The third plane, the personal plane called participatory appropriation could only be applied to explain the activity in the case of one of the teachers, E, during the beginning teaching phase. In the participatory appropriation plane of analysis, the participants change, make ongoing contributions and subsequently engage in similar activities. This is a dynamic plane and based on this difference, Rogoff (1995) contrasted the notion of internalization with appropriation. Internalization is a static concept in which the person imported the external and fitted into personal purposes. This is comparable to the internalization model in teacher socialization studies (Lacey, 1977) which was explained as the situation where an individual teacher conforms to the institutional culture or practice. The participatory appropriation plane of analysis attaches much importance to the notion of individuals participating, in being involved in and contributing to the activity which in itself is evolving as a result of the participants. The process involves communications and adjustments in understanding among the participants. The participants may then arrive at new but common understandings about social processes. In the process, previous experiences and participation in the activity modify subsequent contribution as well as plans for future activity. This is an on-going, dynamic process that emphasizes the communication between the participants, which stimulate adjustments.

In the study, the way that teacher E and the other teachers teaching the same level in the school were engaged in an activity can be explained with a participatory appropriation plane of analysis. For teacher E the resource pack is an external idea as compared to the practice in the school. He did not just internalize the ideas or import them into his own teaching but also shared them with other teachers in the school. Through this sharing, new meanings were made; the teachers contributed their ideas of how the activities can be better implemented in the classroom. The process involved teacher discussions and sharing of ideas and experiences in the implementation. The science teaching inside the classroom of E was not simply a direct implementation of the materials but there were modifications, improvements and detailed planning as a result of the participation of other teachers. The practice of science teaching changed over time among all the participants or teachers during the implementation. As participatory appropriation is a dynamic plane, it is possible that these teachers will pursue further changes in their science teaching after or based on this experience.

In this study, participatory appropriation occurred in one of the teachers at the beginning teaching phase, although this is a preferred model of learning for the teachers in the school, this did not always occur. For most of the student-teachers, the learning process may be described at the apprenticeship or the guided participation plane of analysis.

9.4 Towards building a model for teacher development

Drawing together the various points of view that explain the learning process of the novice teachers in the above sections, this section brings the view together into a model as depicted in Figure 9a. The model draws upon the view that learning to teach is a sociocultural activity. This explains how the interventions in the present study may support the development of the novice teachers. Moreover, it highlights the interactions between the researcher, the novice teachers and the school culture. These interactions have a significant influence on the development of the novices.

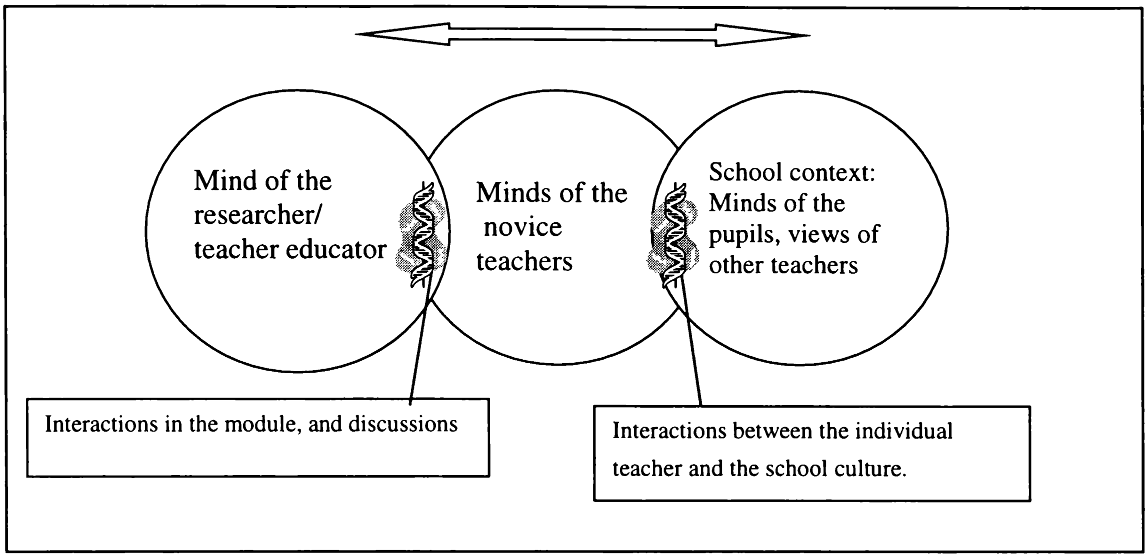

Figure 9a Representation of a model for teacher development

In the centre of the model are the minds of the student-teacher or the beginning teachers who came with their past experiences in learning and teaching science. The experiences of past science education may have had an influence on their views of science teaching and learning. In the Curriculum Studies module, these views and confidence in science teaching were transformed into an awareness of the importance of engaging pupils in thinking in the lessons and the implications of the constructivist view of learning on science teaching. Their confidence also grew in time. Past experiences of science learning were reconstructed by more recent experiences in the Curriculum Studies module and the teaching practice experience.

The circle on the left represents the mind of the researcher/ teacher educator. I started with views of effective science teaching as engaging pupils in thinking and considering the implications of the constructivist view of learning in science teaching. The purpose of the researcher was to help the student-teachers or the beginning teachers to raise their confidence in science teaching and to be able to stimulate pupils to think in science lessons. The teacher educator acting as the agent made use of a number of mediational means to help the novice teachers to become socialized into the culture of science teaching, including the activities and discussions in the Curriculum Studies module and the resource packs. The teacher educator in this case represents the influence from an institutional culture.

The spiral between the left circle and the central one represents the interactions between the researcher and the novice teachers. These interactions included those effected through the discussions in the Curriculum Studies module, where there were also interactions between the novice teachers themselves. Hence, these are not restricted to one to one interactions, but there are also one to the group or between the members of the group itself. The form of the interactions include language, the comparison of views on the inter- and intramental planes and attempts on the part of the novice teachers to recontextualise their learnings in their own situations. Through the interactions, both parties changed or developed. The views of the novice teachers became more consistent with a constructivist view of learning while the researcher learnt more about the learning and the needs of the novice and hence designed further support. In the beginning teaching phase of the study, the resource packs, the workshop and the telephone contacts may be seen as other forms of mediated actions. In addition, the beginning teachers were stimulated by the researcher to reflect more on their teaching in the interactions. The purpose was to facilitate the development of the beginning teachers in the beginning teaching phase. It appears from the findings that the Curriculum Studies module and the support provided by the researcher facilitated the development of the novice teachers such that they adopted a constructivist view of learning as they taught science.

The circle on the right represents the school context, which includes the views of other teachers in the school, the needs of the pupils, and the expectations of the school regarding the teaching of the novice teachers. These together make up the school culture. The spiral between the central and the left circle represents the interactions between the novice teacher and the school context. These interactions include the discussions between the novice teachers and their pupils and other teachers in the school. The former group of interactions occurred mainly in the lessons when the novice teachers tried to mediate the pupils from their preconceptions of science to a science literate culture. This mediation involved the choice of a number of activities from their tool kit of various teaching strategies that they know of. The application of which strategy to take depends largely on the second group of interactions, that is those with other teachers in the school or the school context. In this process, the novice teachers recontextualized what they learnt from the Curriculum Studies module or the materials in the resource packs into their situations. For some teachers, the spiral shifts more to the side of the novice teachers where science teaching means engaging pupils in thinking. For others, the spiral of interaction shifts more to the school context where learning means to remember and score better results in tests.

Through these two levels of interactions, there were changes in the parties involved. The interactions between the teacher and pupils, which were mainly in the form of language, come to shape the pupils' thinking during the science lessons. During these lessons, the pupils realize over time how the teacher encourages their responses, questions and even follows up on the teacher's questions. This change was more obvious in the lesson taught by teacher L during the beginning teaching phase.

The interactions between the novice teacher and other teachers in the school result in changes in the teaching activities in the science classrooms over time. The interactions between the beginning teachers and other teachers in the school were more significant for teacher E which resulted in changes in the teaching of other teachers. However, these interactions may or may not occur in schools. In schools where these interactions do not occur, the beginning teachers may need to choose their science teaching strategy depending on their perception of the needs of the pupils and the influence of the school.

From a panoramic view, this learning process has effected a transfer of the institutional culture to the school through the teaching of the novice teacher. Thus, this may result in changes to the teaching of teachers in the school. Moreover, the school context also informed the teacher education strategies. Having learnt the needs of the novice teachers and the school context, the teacher educator also modified the intervention. This transfer is represented by the two-way arrow over the top of the model.

These circles represent a dynamic model in which the circles may overlap more with one another if the beliefs of the different parties converge. There may also be cases where two of the circles converge more with each other than with the third, for example, in cases where the researcher and the novice teacher hold similar beliefs of science teaching, the central and the left circles overlap more with each other. The spiral may also be shifted towards one end or another depending on the perceived influences from the two cultures as seen by the novice teachers. Finally, the circles have to be considered with reference to each other, as learning is seen not as a solo activity but a person-plus social surround activity. The interactions between the parties are essential for understanding the development. The picture is also a fluid one in which the circles may move relative to each other and the views in the minds of the parties may also change or develop over time.

Chapter 10
Conclusion and implications

10.1 Introduction

The previous chapter theorised the development of the student-teachers in terms of their professional, social and personal aspects. This adds to the main argument that the process of learning to teach may be explained with a sociocultural view of learning. This chapter summarizes the data analysis that supports viewing teacher development as a sociocultural process. Based on the findings and the explanations, the implications of the study and recommendations for teacher educators and science teachers are made. Finally, the limitations of the study and suggestions for further study are made.

10.2 Teacher development and learning to teach

In this thesis, the student-teachers and the beginning teachers were regarded as learners in a process of learning to teach. Teacher development is explained as a sociocultural activity. The student-teachers and the beginning teachers may therefore be considered as novices being socialized into a new culture of science teaching. As a sociocultural activity, teacher development is a situated and contextualised activity. It is shaped by the context, which includes the settings of the teacher education institute, the classroom and the school. Moreover, the actions of the teacher educator in facilitating the development of the novices are purposeful activities that aim to help them to socialize to a culture of teaching science based on a constructivist view of learning.

First of all, facilitating the development of the novice is a situated and purposeful activity. The teacher educator can be regarded as an agent who made use of both mediated actions and mediational means in the process. In the present study, the purpose of the teacher educator was to help the student-teachers to teach science based on a constructivist view of learning. The mediated actions included the delivery of a Curriculum Studies module (Section 3.5.1) at the first phase of the study, as well as the provision of support during the teaching practice and the beginning teaching phase. Mediational means included the opportunities for discussions in the module sessions, the use of a topic "air" (Appendix D) to illustrate what teaching science based on a constructivist view of learning means, and the use of a resource pack at the beginning teaching phase. It appears that these interventions facilitated the novice teachers to teach science with the intentions consistent with a constructivist view of learning, to perform the teacher actions that help to engage pupils in thinking in the lessons (Section 8.3.2), to develop better learning outcomes (Section 8.4.2), and learning conditions (Section 8.4.1) as well as experience gains in their confidence in teaching science (Section 8.5.2).

From a sociocultural view of learning, teacher development is seen as a contextualised activity. The context of the teacher education institute or the beliefs of the teacher educator shaped the purpose or the intentions of the teacher educator. Thus, the interventions and effort to support teacher development are contextualised in a culture that values teaching science based on a constructivist view of learning. For the student-teachers in the teacher education programme, other cultural or contextual influences were acting on them, such as how other teachers taught in their past educational experiences, and how other lecturers taught in the science academic studies module in the first year of the programme. It may be interpreted that these influences led to the concerns about science teaching before the module, and to views about science teaching as mainly involving in teaching the content or conducting practical activities.

The second context at work in the teacher development process in the present study was the teacher education programme. This is a context that comes with the delivery of the various forms of support and the Curriculum Studies module. As suggested by the findings about the professional (Section 9.1.1), personal (Section 9.1.2) and social development (Section 9.1.3) of the novice teachers, this context tends to facilitate the teachers to teach science based on a constructivist view of learning. Moreover, the support from the peers of the student-teachers and the beginning teachers facilitated each other's development.

The third context that came into play is the school context, which influenced the teaching of the novices starting from their teaching practice to their beginning teaching phase. The norm of minimal lesson preparation, few opportunities for practical activities, and heavy reliance on the textbook seemed to create a dilemma for the novices (Section 7.3.4). They had to decide in their own science teaching as to whether they would follow the norm or continue with their efforts to engage pupils in thinking in science lessons (Section 7.3.2). The findings suggest that some of the novices reduced their activities or interactions and reverted to a stronger adherence to the textbook three months after beginning teaching. At this point, they communicated to the researcher about the need for support in terms of resources and discussions about teaching (Section 7.5). The influence of the school context seemed to lessen with the use of the resource pack and the discussions with the researcher. The beginning teachers began to raise their concerns about pupils' preconceptions and ways to engage pupils in thinking (Section 8.2.4). However, the concerns about the practices of the school or other teachers were important as the beginning teachers considered how to implement the activities or make use of the materials in the resource packs (Section 8.2.1; Section 8.2.2). Despite this, one of the beginning teachers managed to influence how other teachers taught in the school and shared the resource pack with them (Section 8.2.3). The culture of how teachers teach science in that particular school therefore underwent some changes as a result of this study. On the whole, the two main contexts shaping the teaching of the novice teachers included that of the teacher education programme and that of the school. These two contexts had different cultural backgrounds and both influenced the teaching of the novice teachers.

In explaining teacher development as a sociocultural activity, interactions with the researcher and with peers are important in both the teaching practice and the beginning teaching phase. These interactions shape the thinking of the individuals and socialize them into the new culture of teaching science. The student-teachers compared the interactions that they experienced in the Curriculum Studies module with the interactions that they promoted with the pupils in the science classroom. In the beginning teaching phase, the interactions between the researcher and the beginning teachers helped to clarify the purpose of the materials in the resource packs. The interactions between the teachers in the school with the beginning teacher E helped the latter to socialize other teachers into a culture of teaching science that values lesson preparation and the use of practical activities.

In explaining teacher development as a sociocultural activity, the three planes of analysis as suggested by Rogoff (1995) may be applied. The learning of the student-teachers in the Curriculum Studies module with the guidance of the teacher educator and the peers as resources and challenge for each other may be viewed using the apprenticeship plane of analysis. The interactions between the student-teachers and the teacher educator at the teaching practice and the beginning teaching phase may be compared as social partners who communicate and coordinate their efforts. The shared purpose was to improve the quality of teaching in the primary science classes. The participatory appropriation plane of analysis may be used to explain the involvement of teacher E with other teachers in the school. This emphasized on the dynamic nature of the relationship when the teaching culture in the school underwent changes through the interaction between teacher E and other teachers. On this basis, there may be further interactions and changes in the teaching of the individual teacher (E) or other teachers in the schools in future.

Teacher development can therefore be viewed as a sociocultural activity that is a situated and contextualized activity. In this activity, interactions between the participants shaped the thinking and socialization of the novice teachers into a culture of teaching. Moreover, the interactions between the participants in the process may be explained by using the apprenticeship, guided participation or participatory appropriation planes of analysis.

10.3 Implications and recommendations

This study started off with the purpose of identifying ways to support the learning of the novice teachers and identifying a model for teacher development. In chapter nine, the professional, personal and social developments in the process of learning to teach science were summarized (Section 9.1), and a model of teacher development was proposed (Section 9.4). The model was built on a sociocultural view of learning which emphasized on the interactions between the novice teacher with the institutional culture or the mind of the teacher educator on one hand, and the interactions between the novice teacher with the school context on the other. The present study adds to the existing literature in several ways which includes: contributing to the knowledge about teacher education in the Hong Kong context, bringing an understanding of how teachers in Hong Kong may teach science based on a constructivist view of learning, and using a sociocultural view of learning to analyse teacher education. Based on these findings, implications for the possible forms of support in the learning process of the novice teachers are drawn.

The implications about the forms of support address the two phases of teacher development: preservice and beginning teaching. Moreover, the beginning teaching phase is seen as a linkage between the institutional and the school culture and forms part of the socialization process of the novice teachers. At the preservice phase, implications can be drawn by considering the mediated actions, the use of language, and the interactions between the participants and the importance of science knowledge in teaching. At the beginning teaching phase, learning from the institute is contextualised and can be explained by considering the interactions within the school context.

The first implication is drawn by considering the mediated actions based on a sociocultural view of learning. When the teaching of science teachers, is seen as a process of socialization into the culture of science teaching, the teacher educator needs to help the student-teachers to be aware of the existence of the different cultural influences in schools. While introducing the various teaching approaches in science teaching, the purpose behind them needs to be discussed, as well as how different cultures of science teaching may influence the application of the approaches. The strategies that the teacher educator employs in facilitating the learning of the novice teachers are regarded as mediated actions. As mediated actions are goal directed, the teacher educator has to be conscious about the purpose and the goal that the actions serve. In addition, considerations need to be made to see how these actions may influence the subsequent views of the student-teachers.

The second implication emphasizes ~~on~~ the importance of interactions and language in the process of learning to teach. As the learning process is one of socialization, the student-teachers are not seen as passive learners who may just internalize the external practices. They are seen to be active in interacting with the context or the new culture of science teaching at the intermental plane with the teacher educator. This interaction is based on their previous views about science teaching and learning which made up the intramental plane. The teacher educator therefore needs to be aware of such interactions and the experiences of the student-teachers to consider how the interactions between the two planes may better result in socialization into the new culture of science teaching.

While mediated actions are important in facilitating the learning of the student-teachers, language is one of the mediational means. Language forms a linkage between the mind of the student-teachers and that of the new culture of science teaching. The teacher educator has to be aware of the important role that language plays in the learning process of the student-teachers. Opportunities for discussions, peer interactions and teacher-learner interaction are important. Through the discussions, the teacher educator may also better understand the thinking of the student-teachers.

The third implication arises from the notion of the tool kit approach in explaining teacher education. Discussions and the activities in the Curriculum Studies module make up the tool kit of the teacher educator. The use of a particular tool needs to come with a purpose in mind and needs to be matched to the culture shaping the tool. For example, the teaching strategies to be used with pupils in schools and introduced by the teacher educator were based on a constructivist view of learning. Having a learning experience with these teaching strategies, the student-teachers were influenced by a science teaching culture that values a constructivist view of learning. While the teacher educator has a number of mediational means or tools in mind, the use of each carries the cultural influence shaping it. Therefore, in order to convince or socialize the student-teachers into a culture of a particular teaching approach, the teacher educator needs to practice the same approach or adopt tools that are designed with the same cultural influence. Otherwise, the student-teachers may be socialized into other unintended cultures of science teaching, or find themselves confused by the different cultures. This means that the related modules about science and science teaching need to adopt a consistent teaching approach or tools that are shaped by the same approach of teaching in science.

Since the process is a dynamic one, the teacher educator needs to acknowledge the contributions from the participants in the process and be open to continuous improvement. In the present study, the teacher educator learnt more about the concerns of the beginning teacher from the process, and new implications about helping student-teachers to teach science are drawn. For example, at the beginning teaching phase, the teacher educator learnt about the needs of the beginning teachers in having resources and social support for their science teaching. The teacher educator thus provided the support for the beginning teachers based on their needs.

The fourth implication looks into a comparison between helping novice teachers and the pupils in their learning. As the teaching of pupils in the school can also be viewed as a sociocultural process, helping novice teachers to teach science is then a process that prepares them to be mediators of this process. The above emphasis on engaging learners, in this case, the pupils discussing and being involved in intramental to intermental actions, applies. The pupils come into the science classes with their preconceptions acting on the intramental plane and interact with their peers and the teacher on the intermental plane. The student-teachers need to be made to be aware of the importance of the exchange. This is one of the ways to get pupils thinking in the lessons. Moreover, in a similar way, the interactions or exchange informs the teachers about their teaching, and they need to be ready to use this information to improve their teaching.

As observed in the interactions of the lessons of teacher L, the pupils and the teacher provided a lot of opportunities for interaction (Section 8.3.3.3) and this led to more active thinking by the pupils (Section 8.4.1). Both the teacher and the pupils were engaged in dialogue and continuous thinking. Over time, the teacher improved her practice and the pupils got used to being engaged in interactions that required thinking in the lessons. This improvement needs to be one that the teachers aim for in their lessons.

The fifth implication draws on the notion of a tool kit approach in explaining the development of teaching strategies among the student-teachers. Basically the student-teachers need to be equipped with a range of mediational means or a tool kit that helps them in their science teaching. The tool kit can be seen to comprise of a variety of teaching strategies, science teacher knowledge and the language to communicate with the pupils about science. Science teacher knowledge is made up of not only the science content knowledge, but other forms of knowledge are also essential. Shulman's (1987) definition of Pedagogical Content Knowledge includes ways of representation of the knowledge as well as a consideration of the learner's preconceptions and the ability of the learners. There are two implications of this argument. Firstly, as revealed in the findings in the study, the knowledge of preconceptions, the possible ways of arranging the topic into a logical sequence, the ways of engaging pupils in thinking and ways to encourage pupils to ask questions all contribute to an increase in the confidence to teach science. The concern for science content is not just for science content *per se* but for ways of relating it to teaching. This is the knowledge that the student-teachers need to be equipped with in their tool kit in the teacher education programme. Secondly, the knowledge that is learnt in the teacher education programme is in the Hong Kong Institute of Education is recontextualised when the student-teachers or graduates teach in school. The knowledge and its meaning are recontextualised or reinterpreted. Following this, teacher educators need to understand how the context is going to influence the recontextualisation process and facilitate the recontextualization process, which means providing support in the classroom teaching as the knowledge about science teaching is recontextualized.

Following the above argument about recontextualization of learning in the teacher education programme, the sixth implication looks into the recontextualization of learning of the beginning teachers and the support during the beginning teaching phase. This notion of recontextualization of the learnings of the teacher education programme can be applied to examine the problem of transfer from theory into practice. The contextualization process is part of a learning process and Perkins (1993) argued that we need to consider learning from a person-plus perspective. The contextualization therefore involves not only the novice teachers but also other teachers, pupils and the school principal in the school context as a social surround. This is also shown in the present study that the social surround played an important role as the resource pack or the learnings from the Curriculum Studies module were contextualized. Putting the sole responsibility of learning on the individuals and requiring them to transfer the learning ignores the importance of the social surround. Further, the development of individual teachers cannot be categorised into a pre-determined set of stages or criteria if the person-plus system of learning is considered. The analysis of teacher development needs to take into the consideration that the instructional surround may not mediate the transition, and individual teachers need to be allowed the freedom to decide what they see as best practice in their context.

The teacher educator therefore needs to look at how the system or the context can support the learning of the individual. Thus, the focus needs to be on how to create support from the system in order to facilitate the development of the person. The direction needs to be that of trying to find out ways of coordinating efforts that support teacher development within the school and the teacher education institute.

Due to the interaction between the school and the institute culture, the support for teacher E resulted in improvements in both the novice teacher and the system or the school. This is congruent with a participatory appropriation plane of analysis in which the individual and participants in the system modify the shared action and improve the practice. The apprenticeship plane of analysis and the guided participation plane of analysis can be used to explain learning in the teacher education programme, while the participatory appropriation plane of analysis is one that teacher educators or the schools need to aim for in order to improve practice.

Based on the conclusions and the implications of the study, a number of recommendations for teacher education and science teaching are made. The recommendations for teacher educators and the teacher education programme at the Hong Kong Institute of Education are as follows:

- The content and pedagogy modules in the teacher education programme need to be introduced with a similar approach or from strategies stemming from similar institutional cultures. Helping student-teachers to teach is viewed as a process of socializing the student-teachers into a new culture of teaching. The teacher educator needs to model the teaching approaches advocated and see herself or himself as an agent of the teaching culture. All the teaching actions are mediated actions that carry cultural meanings, which may have an influence on the subsequent teaching of the student-teachers.
- The lecturers need to give more consideration to the past learning experiences of the student-teachers as these may inform them about the interactions between intermental and intramental planes. By acknowledging the past experiences of the student-teachers, the teacher educator may be able to design adequate learning experiences that suit the needs of the student-teachers and be aware of how they may interpret the meaning of the experiences on an intramental plane. Moreover, the interactions between the student-teachers and between the teacher educator and the student-teachers at the intermental planes form part of the learning as well as facilitate changes in the intramental planes.
- The lecturers need to be aware of the goals of the mediated actions and evaluate their own teaching against these goals. For example, the teacher educator has to be aware about what kind of science teaching is to be promoted among the student-teachers. Furthermore, if the goal of the teacher educator is to help the student-teachers to teach science based on a constructivist view of learning, the evaluation of the teaching would be to see how far the student-teachers are able to implement the related strategies in their science classrooms.
- Discussion through the use of language shapes thinking among the individuals and the participants as a group. Opportunities for student-teachers to exchange their views are essential in the programme.

- The lecturers need to have an open mind and continue to develop new strategies in addressing the needs of the student-teachers.
- The contextualization of the theories learnt in the teacher education programme should not be left to chance alone. The Institute needs to consider providing support based on the needs of the novice teachers during the teaching practice and the beginning teaching stage.
- The supports for beginning teaching have to address the needs of the novice teachers as they learn to be participants in the school system. Ways of collaborating the support between the Institute and the school need to be identified. This support needs to aim for teacher and school development through an interactive process between the two parties.

The recommendations for science teachers in Hong Kong include:

- Science teachers need to engage pupils in thinking and change the way pupils think about science through classroom interactions.
- Pupils respond to the teachers' teaching through the interactions in the science classes that get them thinking. It requires time to change the pupils who are used to learning in a transmission approach.
- Science teachers need to be aware of the possible teaching approaches and the cultural implications of their application, for example, the view of learning that is underpinning the approaches.
- Teaching science with a constructivist view of learning may also end up with better scores in examinations. The transmission approach is not the only tool in the tool kit.
- Science teachers need to respond to the needs of the pupils and prepare to change their teaching strategy. There are new learnings among the teachers during their interaction with the pupils.

10.4 Limitations of the research

This research did not address certain issues. Firstly, while the present study involved an intervention in the Curriculum Studies module, the problem of poor science background of the student-teachers remains unsolved. The novice teachers reflected their perceived difficulties in answering pupils' questions. This is however out of the scope of what the researcher can manipulate. A recommendation would be to introduce a science academic studies module that is taught with an approach consistent with that in the Curriculum Studies module. This would mean a change in the intervention of the present study, instead of attempting to help student-teachers to teach science based on a constructivist view of learning through a Curriculum Studies module. The intervention will be introduced in a module where science academic knowledge is taught with an approach consistent with the strategies advocated.

Another unresolved issue is the relatively low importance of science in the primary curriculum, thus leading to a general feeling among teachers that science learning is of low priority in their teaching. This is a more difficult problem as solving it may mean a re-structuring of the primary curriculum.

Another limitation of the study is that of the dual role of the researcher. In the present study, the researcher is also a teacher educator who provided the support to the student-teachers and after they graduated from the programme. The student-teachers also realised that the support and the data collection were part of a research study. This relationship may have led to the situation that the student-teachers or the novice teachers tended to provide positive support to the researcher and teach in ways that were congruent with a constructivist view of learning while the lesson observations were made.

The dual role as a researcher and a teacher educator has also led to limitations in the data collection process. As the researcher is also the facilitator of the Curriculum Studies module sessions, the workshops for the student-teachers before their teaching practice and the workshop when the resource packs were introduced, data collection or making observation as a researcher were not possible. The researcher was engaged in having discussions with the novice teachers and conducting the activities in the workshops. However, these workshops and sessions may have also provided data on how the interactions between the novice teachers may support their development.

The last limitation arises from the local context in which the study was conducted. The present study was conducted in the Hong Kong context where teachers in general teach with little lesson preparation or planning and adhere very closely to the contents in the textbook. The development of the student-teachers or the beginning teachers contrasted sharply with the current practice. In this case, the results of the study can only be generalised for this particular kind of teaching context and may not be applicable to other places when the teaching culture is different, for example where teachers in general have more interactions with the pupils or tend to prepare more activities or group work for their pupils.

10.5 Suggestions for further study

A number of possible studies can be pursued based on the findings of the present study. These include:

Studies can be conducted to identify how actions within teacher education are mediating the learning of the student-teachers and socializing them into the culture of teachers in general.

Possible ways of collaboration between the teacher education institute and the primary schools could be drawn up. Studies can then be set to evaluate the effectiveness of the attempts in facilitating the contextualization of the learning.

Teachers in the same school need to be encouraged to have more interactions and sharing about their teaching. In-service teacher development programmes that aims to stimulate teachers to share the materials and ideas and to discuss about their teaching can be investigated.

Appendix A
Interview questions

Appendix A1 Interview questions for student-teachers before or at the start of the Curriculum Studies module

Professional

1. What do you think is or are the important things that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?)

2. Is science more, or less, or equally important for primary children as other subjects like English, mathematics, etc.?

3. What do you think science is? How would this view of science influence your teaching? What is the role of the teacher in science teaching?

4. With reference to science teaching, what are the steps in your lesson preparation?

5. When you teach science, what are the most common strategies that you would employ? What are the reasons or principles for choosing these strategies?

6. Do you think that pupils have some preconceptions in science before they go to the science lessons? What would you do if you found out that pupils have such preconceptions?

Personal

1. Does the present 2PC course have any influence on your science teaching? What are the influences?

2. Can you describe your past experience in learning science? (Have the teachers who have taught you before had any influence on your teaching? What are the influences? OR Does your experience as a student have any influence on your teaching? What are the influences?)

3. How do you feel about having to teach science topics in General Studies?

Appendix A2 Interview questions for student-teachers after the Curriculum Studies module and before the teaching practice

Professional Development:

1. What do you think is or are the important things that pupils should learn in their science lessons? (What are your primary concerns about the teaching of science?) Have your views changed? If so how and why?

2. Is science more, or less or equally important for primary children as other subjects like English, mathematics, etc.? Have your views changed? If so how and why?

3. With reference to science teaching, what are the steps in your lesson preparation?

4. When you teach science, what are the most common strategies that you employ? What are the principles in choosing those strategies? (Or What do you remember about the strategies that we have covered in the module? What do you think about their applicability in your situation?)

5. How do you feel about studying the Curriculum Studies module? Has the module had any influence on your science teaching? What are the influences?

Personal Development:

1. How do you view yourself learning to teach science?

2. How do you feel about having to teach science topics with a constructivist view of learning?

Social Development:

What does it mean to you to be a teacher of science?

Appendix A3 Interview schedule for student-teachers after the teaching practice

Professional Development:

1. Have your primary concerns about the teaching of science, and your view of what the most important things that pupils should learn in their science lessons are, changed? If yes, in what way?

2. Is science more, or less or equally important for primary children as other subjects like English, mathematics, etc.? Have your views changed? If so how and why?

3. How actually did you go about teaching science topics in the teaching practice?

Discuss: the preparation, the activities you employed, the principles behind them, classroom management, assessing pupils' learning and if there are any really successful lessons that you remember.

(The above questions will reveal how the student-teachers teach science e.g. the way they use the textbook, if they ask pupils to read about a topic, how they use worksheets and experiments, etc. This will show if the student-teachers take into account pupils' thinking when teaching.)

4. What significant events occurred during the teaching practice (this period) that influenced your practice in teaching and learning science at the primary level?

Personal Development:

1. How do you feel about being a science teacher?

2. How do you view yourself learning to teach science?

3. Has the teaching practice had any influence on your confidence to teach science? What are the influences? How do you feel about having to teach science topics with a constructivist view of learning?

Social Development:

1. How would you describe your relationship with your pupils?

2. How would you describe your relationship with other teachers and the school principal? (How does this compare with the time of student-teaching?)

3. In your view, what does it mean to be a teacher of science?

Appendix A4 Interview questions for beginning teachers three months after beginning teaching

Professional Development

1. What do you think is or are the important things that pupils should learn in their science lessons?

2. How would you compare science with other subjects like English and mathematics, etc.?

3. With reference to science teaching, what are the steps in your lesson preparation?

4. When you teach science, what are some common strategies that you would employ? What are the reasons or principles for choosing these strategies?

5. To what extent were you thinking of a constructivist view of learning during the lesson? Did the curriculum studies module have any influence on your present science teaching? What are the influences?

6. How would you compare the teaching now with your teaching as a student teacher? What are the main differences?

7. What significant events occurred during this period, or what are the factors that influenced your views of teaching and learning science at primary level? What are the implications on your practice of teaching science?

8. Do you have any suggestions on how to support the teaching of beginning teachers? What support did you receive? What additional support would have been helpful to you?

9. Did you reflect on your teaching? What was it like? What help would you like to enable you to do more?

10. What feedback did you receive? What additional feedback would have been helpful to you?

Personal Development

1. How do you feel about having to teach science topics in General Studies?

2. How do you perceive your future development in teaching science, in terms of teaching skills and confidence?

Social Development

1. What does it mean to be a science teacher in school? Has your view changed? What is influencing the way you see this?

2. Are you the same sort of GS teacher as other teachers in the school?

3. What do you see as the role of the teacher in students' learning science?

Appendix A5 Interview questions for beginning teachers during the implementation of the resource pack or after the lesson observations

Professional Development

1. How do you feel about the lesson you have just conducted?

2. What were your intentions in the planning and have they been achieved in the lesson?

3. How differently have you taught compared to other science lessons?

4. What are the ways that you have used to stimulate pupils to think?

5. What are the ways that you have helped pupils apply their new ideas?

6. How did you go about finding out pupils' ideas? Having found their ideas what did you do next?

7. What do you think about the pupils' learning in the lesson? Has better learning occurred?

Social Development

1. Did you discuss with your colleagues or peers the use of the materials in the resource pack? What were the discussions about?

Personal Development

How do you feel about using the materials designed in the package?

Appendix A6 Interview questions for beginning teachers after using the beginning teaching resource pack

Professional Development

1. Can you describe how you have used the resource pack?

2. What do you think are the strengths and weaknesses of the resource pack?

3. Has the use of the resource pack influenced the way that you look at what is most important in science learning?

4. Has and will the use of the resource pack influence your choice of teaching strategy? What are the influences and why?

5. What are the influencing factors that may affect the implementation of the materials in the resource pack?

6. Do you have any suggestions on how to improve the resource pack or support the teaching of beginning teachers?

7. What is your view of teaching in general? How do you think children learn best? How has your view changed compared with before your graduation?

Personal Development

1. Does the resource pack have any influence on your confidence in science teaching? What are the influences?

2. How would you perceive your future direction in teaching science, in terms of teaching skills and confidence in using the resource pack?

Social Development

1. Did you discuss with your colleagues or peers the use of the materials in the resource pack? What were the discussions about?

2. What were the reactions of the pupils towards the activities suggested in the resource pack? How would these influence your teaching and confidence?

*Other questions to be included as arising from the teacher's journals, pupils' work and the questionnaire findings.

Appendix B
Journal forms

Appendix B1 Journal forms before the implementation of the resource pack

Part I

Try to recall the three most impressive science lessons in the General Studies subject and write down:

i) the theme of the lesson, the preparation before the lesson, and your consideration of the teaching method,

ii) what happened in the lesson and what activities were conducted

iii) your feelings after the lesson.

The theme of the lesson:

Preparation before the lesson:

The teaching method

Pupils' responses

Your feelings after the lesson
(Are you satisfied with your teaching? Do you think the pupils learnt effectively? Did you attempt to use the interactive approach or try to find out pupils' preconceptions? What kind of support would you like to have?)

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Appendix B2 Journal forms after the implementation of the resource pack

Part I

Recall the six most impressive lessons since you implemented the materials in the resource pack, and write down:

i) how you implemented the materials in the resource pack;

ii) what happened in the lesson, what were the activities, how did the pupils respond, and what questions were raised;

iii) how did you respond to the pupils' questions?

iv) Do you think that the activities can stimulate pupils to think, and how do they stimulate the pupils to think?

v) Do you think that the lesson is successful? What is the reason for the success or the failure?

vi) What would you do if you teach the same topic again?

vii) What kind of support would you like to have?

Part II

Topic: ______________Date: _______ Class: _____

(i) The implementation of the materials in the resource pack:

____
____
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(ii) what happened in the lesson and what were the activities

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(iii) Pupils' responses

(iv) What questions did the pupils raise?

(v) Do you think that the activities can stimulate the pupils to think? How?

(vi) Do you think that the lesson was successful or not? What is the reason for its success or failure?

(vii) What would you do if you teach the same topic again?

(viii) What kind of support would you like to have?

Appendix C
Questionnaires

Appendix C1 The student-teacher background questionnaire

Student-teacher Background

Below are some questions about you and it would be helpful for us in analysing the data. Please circle the appropriate number beside the answer.

1. Sex
   1. Male
   2. Female

2. The subject that you studied in Form 7
   1. Arts
   2. Science

3. Before you entered the present programme, did you have any full-time working experience?
   1. Yes
   2. No

4. Before you entered the present programme, did you have any full-time teaching experience?
   1. Yes
   2. No

5. The number of credit points that you studied on science academic studies and science curriculum studies:
   1. Academic studies __________
   2. Science curriculum studies __________

6. Did you teach science-related topics in the General Studies in the teaching practice?
   1. Yes
   2. No

7. Is teaching the first choice for your career?
   1. Yes
   2. No

8. Do you regard teaching as your life-long career?
   1. Yes
   2. No

9. Did your enthusiasm to teach change in this teacher education programme?

1. Yes
2. No

10. Did you find teaching a suitable choice for you?

1. Yes
2. No

11. Can you give five reasons for choosing teaching as your career?

1. The most important reason is: ______________________

____

2. ____

3. ____

4. ____

5. ____

Appendix C2 Science Teacher Efficacy Beliefs questionnaire

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. Please consider each in the context of primary teaching in Hong Kong in relation to the teaching of General Studies.

5 = strongly agree
4 = agree
3 = uncertain
2 = disagree
1 = strongly disagree

1. When a student does better than usual, it is often because the teacher exerted a little extra effort in getting pupils to think.	5	4	3	2	1
2. I am continually finding better ways to teach science-related topics.	5	4	3	2	1
3. Even when I try very hard, I do not teach science-related topics as well as I do most topics.	5	4	3	2	1
4. When the grades of students improve, it is often due to their teacher having found a more effective teaching approach.	5	4	3	2	1
5. I know the steps necessary to teach science-related concepts effectively.	5	4	3	2	1
6. I am not very effective in monitoring science experiments.	5	4	3	2	1
7. If students are underachieving, it is most likely due to ineffective science teaching.	5	4	3	2	1
8. I generally teach science-related topics ineffectively.	5	4	3	2	1
9. The inadequacy of a student's science background can be overcome by good teaching.	5	4	3	2	1
10. The low achievement of some students cannot generally be blamed on their teachers.	5	4	3	2	1

11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	5	4	3	2	1
12. I understand science concepts well enough to be effective in teaching science topics at primary level.	5	4	3	2	1
13. Increased effort in science teaching produces little change in some students' achievement.	5	4	3	2	1
14. The teacher is generally responsible for the achievement of students.	5	4	3	2	1
15. Students' achievement is directly related to their teacher's effectiveness in science teaching.	5	4	3	2	1
16. If parents comment that their child is having more interest in science at school, it is probably due to the performance of the child's teacher.	5	4	3	2	1
17. I find it difficult to explain to students why science experiments work.	5	4	3	2	1
18. I am typically able to answer students' science questions.	5	4	3	2	1
19. I wonder if I have the necessary skills to teach science-related topics.	5	4	3	2	1
20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.	5	4	3	2	1
21. Given a choice, I would not invite the principal to evaluate my science teaching.	5	4	3	2	1
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	5	4	3	2	1
23. When teaching science-related topics, I usually welcome student questions.	5	4	3	2	1
24. I do not know what to do to get students engaged with science.	5	4	3	2	1

25. Even teachers with good science teaching abilities cannot help some kids to learn science.	5	4	3	2	1

Appendix C3 The science teaching questionnaire

1. When you are teaching science-related topics in General Studies, how often do you employ the following teaching activities?

5 = In every lesson 4 = quite often 3 = sometimes
2 = very rarely 1 = never
0 = not applicable

a. teacher led discussion	a	5	4	3	2	1	0
b. teacher demonstration	b	5	4	3	2	1	0
c. teacher explanation of a science concept	c	5	4	3	2	1	0
d. teacher explanation of the text	d	5	4	3	2	1	0
e. teacher initiated investigations	e	5	4	3	2	1	0
f. pupils discussing in small groups	f	5	4	3	2	1	0
g. pupils discussing as a class	g	5	4	3	2	1	0
h. pupils copying notes from the blackboard	h	5	4	3	2	1	0
i. pupils completing worksheets	i	5	4	3	2	1	0
j. teacher checking worksheets with the pupils	j	5	4	3	2	1	0
k. pupils completing workbooks	k	5	4	3	2	1	0
l. teacher checking workbooks with the pupils	l	5	4	3	2	1	0
m. test	m	5	4	3	2	1	0
n. pupils doing library research	n	5	4	3	2	1	0

2. How much do you agree with the following statements?
5 = Strongly agree 4 = agree 3 = no opinion
2 = disagree 1 = strongly disagree

a. My previous learning experience in secondary and primary school science the has strongly influenced my teaching	a	5	4	3	2	1
b. Pupils can obtain first hand experience about their environment in learning science	b	5	4	3	2	1
c. I will minimise science experiments because they are difficult to arrange	c	5	4	3	2	1
d. I can't teach pupils a concept until they have developed to a level where they are ready for it.	d	5	4	3	2	1
e. My job as a science teacher is to pass on to pupils some of the knowledge which is available relating to the natural world.	e	5	4	3	2	1
f. I should structure lessons and experiments carefully so that pupils can discover for themselves how the world works.	f	5	4	3	2	1
g. It's no good just letting pupils discuss their ideas among themselves. They tend to focus on the unimportant and the irrelevant.	g	5	4	3	2	1
h. Science is a logical, ordered and exact discipline. There is, therefore, no place for personal opinions in the teaching of science.	h	5	4	3	2	1
i. I should try to provide pupils with activities and experiences which they can make sense of in their own terms.	i	5	4	3	2	1
j. There should be much less emphasis on teaching facts. In my science teaching, I should concentrate on developing pupils' understanding of the processes of science and on developing their skills in science.	j	5	4	3	2	1
k. Pupils hold very few ideas about scientific phenomena prior to formal science teaching.	k	5	4	3	2	1
l. Most people (including my pupils) do have their own ideas about how things happen. If these ideas work for them, then I should take such ideas seriously.	l	5	4	3	2	1
m. I should provide pupils with good structured explanations of the text and workbooks for each topic, something they can revise at home and learn.	m	5	4	3	2	1

3. You have taught a topic on air to a class of primary 4 pupils. At the end of the topic, you find out that your pupils think that:

- air is weightless
- water droplets that condense on the surface of a can of soft drink come from the inside of the can.

What would you do in the next lesson? A list of possible teaching activities is given below:

A. Devise situations, e.g. experiments, to challenge pupils' incorrect ideas of properties of air, composition of air and condensation.
B. Reteach the topic with different examples.
C. Reteach the topic, using pupils' wrong ideas as a starting point.
D. Proceed with the next topic because the class did as well as you expected them to do on a difficult topic.
E. Summarize the topic, giving main points and definitions.
F. Repeat experiments which show the weight of air and that air contains moisture.
G. Create a new test to investigate pupils' ideas further, before deciding what to do next.
H. Ask pupils to re-read the textbook.
I. Do experiments in which pupils discover the properties and composition of air.
J. Give extra homework questions from the workbook as drill exercises in revising the properties and the composition of air.

Rank order the activities from "most important" to "least important" and indicate those you regard as essential (ES), as helpful (HP) (but not essential) and as serving little purpose (LP).

Degree of importance	Activity No.	Circle the appropriate category		
Most important		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
		ES	HP	LP
Least Important		ES	HP	LP

Write a paragraph explaining reasons for your choice above.

____

____

____

____

____

____

Appendix C4 The post teaching practice questionnaire

Circle the appropriate number

1. On the whole, do you think that your teaching experience this year has helped to increase your confidence in teaching?
   (1) Yes (2) No

2. Did you teach science topics in this teaching practice period?
   (1) Yes (2) No

3. Your confidence to teach science topics in comparison with other topics in General Studies is:
   (1) greater (2) similar (3) less

4. Your confidence to teach science topics in comparison with teaching Chinese is:
   (1) greater (2) similar (3) less

5. Your confidence to teach science topics in comparison with teaching mathematics is:
   (1) greater (2) similar (3) less

6. Rate the difficult of the following problems in teaching science:

5 means having great difficulty 1 means having slight difficulty
0 means no difficulty

a. understanding pupils' preconceptions	5 4 3 2 1 0
b. having sufficient science academic knowledge	5 4 3 2 1 0
c. conducting activities	5 4 3 2 1 0
d. conducting experiments	5 4 3 2 1 0
e. classroom management	5 4 3 2 1 0
f. stimulating pupils to think.	5 4 3 2 1 0

Appendix C5 The beginning teaching questionnaire

Circle the appropriate number

1. On the whole, do you think that your teaching experience this year has helped to increase your confidence in teaching?

(1) Yes (2) No

2. Your confidence to teach science topics in comparison with other topics in General Studies is:
   (1) greater (2) similar (3) less

3. Your confidence to teach science topics in comparison with teaching Chinese is:
   (1) greater (2) similar (3) less

4. Your confidence to teach science topics in comparison with teaching Mathematics is:
   (1) greater (2) similar (3) less

5. Rate the difficulty of the following problems in teaching science:

5 means having great difficulty 1 means having slight difficulty
0 means no difficulty

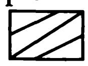
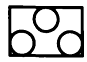
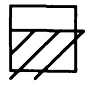
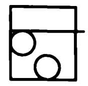
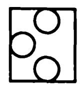
g. understanding pupils' preconceptions	5 4 3 2 1 0
h. having sufficient science academic knowledge	5 4 3 2 1 0
i. conducting activities	5 4 3 2 1 0
j. conducting experiments	5 4 3 2 1 0
k. classroom management	5 4 3 2 1 0
l. stimulating pupils to think.	5 4 3 2 1 0

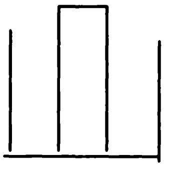
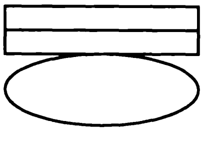
Appendix D
Sample of materials from the Curriculum Studies Module

Below is an exemplary teaching schedule designed based on a constructivist view of learning.
(Used in Session 2)

Primary Four, Age 10
Topic : Air (20 periods in the time-table of the primary school)

Composition of Air		
Possible preconceptions Burning requires air, may not know specifically about Oxygen consumption. Burning gives out smoke, black soot, not know about Carbon Dioxide production. Pupils think that air is made up of one substance. View oxygen necessary for burning but not regard it as a reacting substance. Air contains moisture Pupils may not realise where the water condensed on the can comes from.	Changes in concepts Oxygen in air supports burning. Burning produces Carbon Dioxide. Cutting off Oxygen stops burning. (application: putting out a fire)	Activity or Experiment 1. To focus on or elicit preconcepts. Cover burning candle with glass. What will happen? Why? How will the flame change? 2. Burning candle in a trough of water. Invert glass over candle. Consumption of Oxygen. 3. Lime water test for carbon dioxide. 4. Fire extinguisher. 5. Condensation of water droplets on a can of soft drink.
Properties of Air I: no smell, no taste, exists everywhere, gas state		

Possible preconceptions	Changes in concepts	Activity or Experiment
1. Magnifying, magic glass Draw or represent: nothing in a flask Continuous vs particulate model	Continuous (C)  Particulate (P)  CTV  PTV  PE 	Continuous model 1. Immersing a model "house" into water, analogy that air fills up all "empty" space (also with sugar cube or a piece of brick) 2. See cigarette smoke in a bottle. 3. Difference in weight by same volume of air and water.
If half of the air is taken out, what will be left? Continuous top vacuum CTV Continuous Expanded CE Particulate top vacuum PTV Particulate Expanded PE	See similarity between invisible/ unfamiliar gas behaves like visible / familiar liquid through further experiments. see difference	4. Different compressibility of air and water.
Pupils less sure that air was contained inside a sealed vessel. Associate the presence of air only with the sensation felt when it moved. Not aware that air possesses material, think that air has transient character like 'thoughts'.		
Implications: a. How to help pupils visualise air filling up all empty space in between objects and therefore cannot be partial vacuum model? b. How to help pupils visualise similarities between gas and liquid and differences between them?		

Properties of air II: Air Occupies space and has weight		
Not taking up space, weightless or not having mass. Because gas tends to rise of float. "Gas is light" notion common in years 9 and 10. Air has negative weight. "Float around" rather than "press down". Some pupils associate pressure of air with gravity.	air taking up space weight of air	1. Moving air is wind -- using fan Show that air takes up space -- plastic bag and balloon 2. Invert glass experiments.  3. What weight can a bag of air uphold?  4. Predict the weight of a cup of soda water before and after bubbles have escaped from it. 5. Weight of air balance of uninflated balloons vs inflated balloons

Air and organisms		
Possible preconceptions Increased tendency with age to identify carbon dioxide and oxygen rather than only air. Air is not used by plants or plants and animals use air in opposite ways. Breathing or respiration taken to be synonymous. Pupils know that air is necessary for life, limited idea of what happens to inhaled air.	Changes in concepts Which organisms breath? a man/ a flower/ a leaf/ seaweed/ a grasshopper/ a fish - plant vs animal - land vs water habitat - different types of animals or Which will die in enclosed container? Why? Breathing Man Animal - land, water Plant - land, water	Activity or Experiment 1. Experience of buying goldfish 2. Hydrilla when dark gives out bubbles of carbon dioxide - bicarbonate indicator Breathing: breathe on a mirror, or on hands
Air and Plants		
Possible preconception Disbelief that plants' growth or increase in mass is due to incorporation of matter in the form of gas because of difficulties in accepting that gas is a substance. Believe that plants do not respire at all or they respire only in the dark. 48% of 12-14 years old thought that gas used in photosynthesis enters the plant through the roots or stem.	Changes in concepts Do plants eat at all? How do plants eat? Plants take in oxygen Photosynthesis Take in Carbon Dioxide under light and produce Oxygen Dark, take in Oxygen and give out Carbon Dioxide	Activity or Experiment Hydrilla gives out bubbles of Oxygen in the light, test with relight glowing splint. Starch test for leaves under light and dark conditions. Leaf uses carbon dioxide -- put a leaf in a test tube with bicarbonate indicator.

Air and our Living		
Chemical change, focus attention on one of the participating or reacting materials, regard one material as the cause of an observed change.		1. Rusting: compare different metals; conditions under which rusting occurs. Nail placed at different places inside the house. 2. Air pollution: place vaseline card indoor and outdoor.

Appendix E
Sample of materials from the resource pack on the topic "heat"

Outline of the topic "heat" from the resource pack
Suggested Number of periods: 15

Content	Prior Understandings	Key Concepts	Activities
Heat and Temperature	Feeling hotness from electrical appliances. Pupils need to know what temperature represents – the degree of hotness.	The sun, burning things and some electrical appliances can produce heat. Skin can tell hotness and coldness but it is not accurate.	What do you think will produce heat? What is meant by temperature?
	Experience of using a clinical thermometer. Have seen readings of temperature in weather reports.	We use a thermometer to measure the temperature accurately.	How do we measure the temperature? - using a finger - using a thermometer.
Expansion and Contraction	What is meant by expand or expansion? What does contract or contraction means?	When temperature is high, things will expand. When temperature is low, things will contract.	What is meant by expansion? What is meant by contraction?
	The word expansion means getting bigger or longer. Contraction means getting smaller or shorter.	Thermometers are made based on this idea of contraction and expansion. Other application of this idea is found in building roads, pedestrian cross-overs and railways.	Applying the idea of expansion and contraction.
The transfer of heat	Knowledge of what is metal and non-metals.	Heat is transferred from one end of the object to another.	The transfer of heat from one end of the metal rod to another.
	Experience that metals "feels" hotter compared with non-metals at high temperatures.	Metal is a good conductor of heat and other materials like plastics are poor conductors of heat.	The transfer of heat in rods made of glass, plastic, wood and metal.
		Household utensils are designed based on this idea of good and poor conductors.	Applying the idea of good and poor conductors of heat.

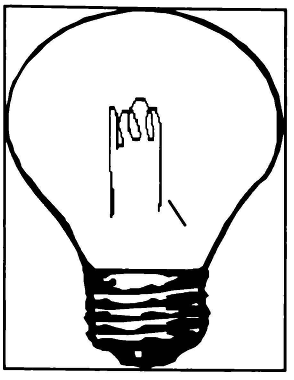
Activity 1 Producing heat

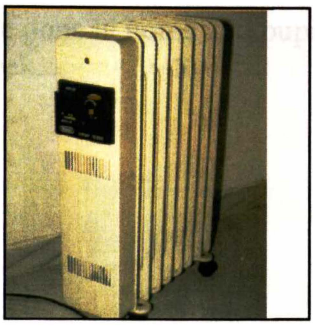
This part helps pupils to realise that there are a number of ways of producing heat. Pupils may have known about various sources of heat production e.g. the sun, fire, by burning something. Knowing that something is hot is different from being to tell how the heat is produced. Burning, electricity and friction are actually methods or means of heat production. The worksheet addresses the question of how heat is produced rather than just stating which are the objects that are hot.

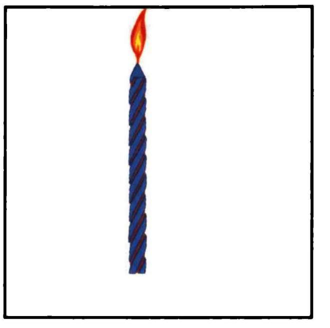
Worksheet

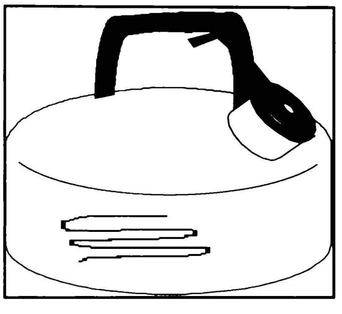
Colour red in the picture the parts that produce heat.

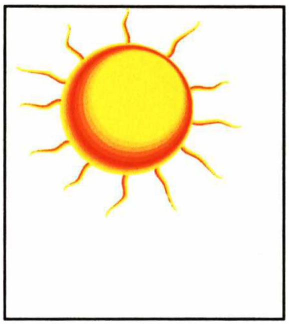
A light bulb | A heater with an electrical filament | A candle

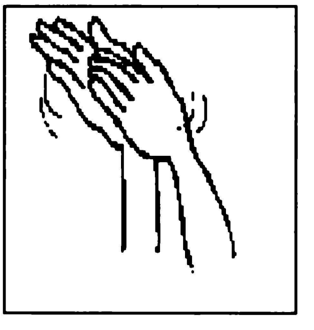












An electrical water kettle | The Sun | Rubbing the hands

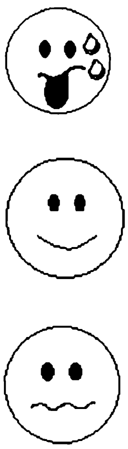
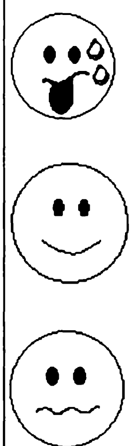
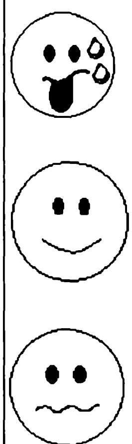
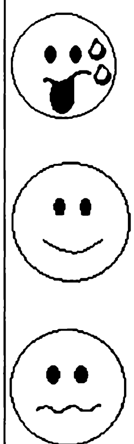
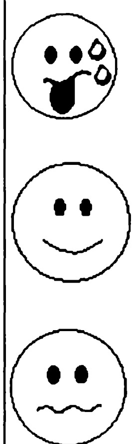
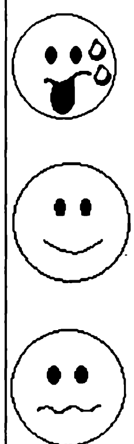
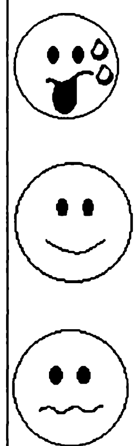
How do you think heat is produced?

Can you suggest other ways of producing heat?

Having coloured the parts that produce heat, the teacher should discuss with the pupils how they think the coloured part can produce heat. The above examples will suggest that electricity and burning produce heat. The teacher can then ask the pupils to suggest other possible ways of producing heat e.g. by friction and eating. Actually, metabolism or, to the pupils, eating is also a way of producing heat.
This part is trying to get pupils to realise that we have met temperature readings in our daily life. The worksheet may be done at home and pupils are asked to record the temperature of the day for the week.

Worksheet

The temperature of this week is:

	Monday	Tuesday	Wednes day	Thurs day	Friday	Saturday	Sunday
Temp era ture							
How do you feel?							

Choose one day to record your body temperature:

My body temperature is _______________. I am / am not feeling well.

The teacher can then discuss with the pupils about the temperature of the week and whether it feels cold or hot with different temperatures. The pupils will also note their own body temperature.

Measuring temperature therefore means measuring the degree of hotness or coldness. The teacher can ask the pupils to feel the temperature of a cup of water and tell whether it is hot or cold.

Worksheet

Put your finger into the cup and tell your classmate how hot the cup of water is. Ask another classmate to feel the water and tell the group how hot it is.

Now put your finger into a cup of ice water and put it into the cup of tap water. How does it feel? Why?
The icy water is _______________ and the tap water is _______________.

Put another finger into the cup of warm water and put it into the tap water again. How does it feel? Why?

The warm water is _______________ and the tap water is _______________.

Why does the same cup of tap water give you different feelings of hotness?

How can we tell the temperature of the cup of tap water?

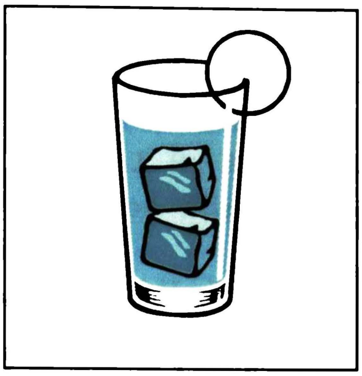
Activity 2 Measuring temperatures

The teacher can start the discussion by referring to the experience of measuring their body temperature. The pupils have used the clinical thermometer and the teacher can ask them to give a description of how to use it. The teacher can also give other examples of thermometers like the one that is used for recording room temperature. Then the activity is about how to use the thermometer.

Worksheet

Can you read the temperatures in the picture?

A cup of cold soft drink



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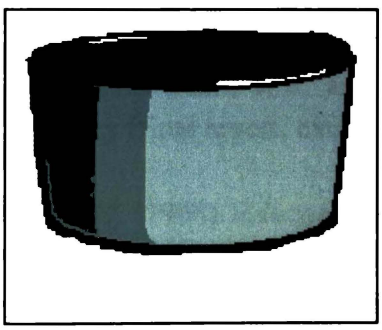
A cup of hot soup

____

The temperature of water in the bath tub



____

A cup of tea

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