SCIENCE AND MATHEMATICS EDUCATION CENTRE

THE EFFICACY OF A CONSTRUCTIVIST APPROACH TO THE TRAINING OF CHINESE MATHEMATICS TEACHERS

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature: --

Date: 16 Dec 2002

ABSTRACT

This action research study was conducted to investigate the efficacy of a constructivist approach to the training of first-year Chinese student mathematics teachers in the Hong Kong Institute of Education where I am employed. A four-stage teaching model was designed, based on the learning theory of constructivism and taking into particular consideration the characteristics of Chinese learners: the maintenance of hierarchical and group harmony and high achievement motivation.

In order to determine whether the application of this model in a methodology class could alter the teaching beliefs of newly enrolled students, a two-phase procedure was employed. First-year students in each phase of the study were involved in solving a teaching problem. Through self-articulation, group- and class-discussions and self-reflection, the students were examined to determine any change in their beliefs about teaching mathematics. Prior beliefs about mathematics teaching, and beliefs held at the end of the methodology module were determined and compared in order to determine if new learning was in evidence. The creation of an authentic interactive learning environment to foster the kind of learning desired – a potentially safe, trusting and non-judgemental environment for free disclosure of students' opinions and feelings about mathematics teaching – was investigated. Data was generated by different quantitative and qualitative methods. Findings were cross-checked by a critical colleague and through my observation and reflections, and these were recorded as clearly, orderly, and accurately as possible. The first phase results were employed to inform and to improve the teaching of the same methodology module in the second phase.

Findings in the two phases were indicative of the creation of a genuine social constructivist learning environment in which student teachers enjoyed their

learning. Student teachers in the second phase implementation of my study indicated an understanding of their role in a constructivist classroom – to construct their own theories of teaching mathematics, to assist their peers in knowledge construction and to learn to learn.

Student teachers in the two cohorts were found to hold entrenched constructivist beliefs about teaching mathematics. They agreed that the teacher's role was a facilitator of learning and that persistent questioning could alter knowledge about mathematics. However, at the conclusion of the module, the Phase I students seemed to re-adopt traditional approaches to teaching, whereas the Phase II students exhibited two different perspectives – an indication of the instability of their teaching beliefs. The Phase II student teachers, nevertheless, showed that they became more aware of sequencing the various interactive activities for their pupils in secondary schools. In the actual teaching, they professed their inability to realise their teaching ideals because of their inexperience in teaching and of the unexpected situations in the school settings.

The present research study adds to the paucity of literature in two areas. First, the employment of a constructivist approach in the preparation of teachers of junior secondary mathematics (for pupils of age between twelve and fifteen), especially in the training of Chinese student mathematics teachers. Second, the study of a higher education lecturer conducting research to improve his/her own practice. Undeniably, further research on models to change student teachers' prior knowledge (about mathematics, about the nature of mathematics, and about the teaching and learning of mathematics), on factors affecting the instability of beliefs, and on models to facilitate continuous development of the teaching professionals are necessary if not exigent.

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CHAPTER ONE

AN INTRODUCTION TO THE THESIS

INITIAL REFLECTIONS ON A TEACHING PROBLEM

Reflections on my work as a lecturer in the Mathematics Department of the Hong Kong Institute of Education (HKIEd) in Hong Kong have motivated me to carry out the present research. The main theme of this study is the development and implementation of a teaching sequence, based on social constructivism, in a mathematics teacher education programme in HKIEd. A well-documented educational problem in mathematics teaching is the use of teacher-centred approaches and the associated limited opportunities for the development of students' conceptual understanding and participation in meaningful classroom discussions. Moreover, I continually find that student teachers of mathematics have been using traditional direct instruction during their teaching practices in spite of the fact that various pupil-centred teaching strategies are introduced in my methodology classes. Why does this happen? Does the practice of the student teachers indicate that my teaching has been ineffective? Is there a problem in my way of teaching?

My duties in the Institute include teaching mathematics subject content and mathematics teaching methodology to both preservice and inservice teachers and supervising students in their teaching practice. Starting from 1994, HKIEd commenced the process of upgrading itself to university status. Consequently, various courses were, and still are being reviewed, revised and restructured. Throughout this review process, academic staff of HKIEd, including myself and my colleagues in the Mathematics Department, debated frequently on various issues encountered.

One of the issues raised concerns the teaching approach lecturers should use in their courses. Until now, the lecture method has been the dominant approach used by academics in HKIEd and indeed by most academics in other tertiary institutions in Hong Kong (University Grants Committee, 1996, p. 97). However, a study by Gow, Kember, and McKay (1996) revealed that two teaching orientations have been observed: transmission of knowledge and facilitation of learning (p. 245). According to Pratt, Kelly, and Wong (1999), Chinese lecturers in Hong Kong tertiary institutions preferred the former teaching orientation, while expatriate western faculty members described themselves as facilitators of learning – though Pratt et al. (1999) realised that one must be cautious in generalising these findings to the wider population (p. 249).

Although many of my colleagues still consider the lecture method the most appropriate in higher education, I started to query the impact this teaching style might have on student teachers. It has been quite commonly agreed that student teachers tend to replicate the kind of teaching approach practised by their school teachers (Fosnot, 1989, p. 9; see also Ebby, 2000, p. 69; Korthagen & Kessels, 1999, p.5). If this is true, then the teaching style of their lecturers in teacher education institutions would have a similar impact on them. It is certainly true that, in general, Chinese students in Hong Kong respect their lecturers, and I could easily see that my own teaching approaches may possibly be regarded as role models for student teachers' future teaching. Consequently, I raised a number of questions for myself and for departmental discussion. These included: If I am using the lecture method in my own tutorial rooms, will this teaching approach be copied and applied by our future teachers? If so, is this what I would like to occur in the mathematics classrooms in Hong Kong schools? Is it paradoxical if, on the one hand, I stress the importance of teachers using student-centred approaches to teach mathematics, while on the other, I am using direct exposition in my class. The dilemma is therefore: Should I maintain the "traditional" transmission method of lecturing, or should I adopt an alternative approach? What alternative approaches would be appropriate for me and my students? How effective would be any new approach I decided to adopt?

Changes in ways of teaching could create potential risks for both student teachers and lecturers in HKIEd – for instance, whether student teachers can cope with any new approach to teaching, and whether lecturers will accept the change – especially when there are current studies reporting students' preference for their instructors' use of the lecture method more than other teaching approaches (Fung & Carr, 2000, p. 381; Pratt et al., 1999, p. 248). This is probably the reason underlying the persistent use of the lecture method by my colleagues and by myself.

There are, nevertheless, reports on the successful trials of different teaching approaches – using the medium of English as instruction – in higher education, including teacher education. For example, Biggs (1998) reported successful implementation of problem-based learning in at least two Hong Kong universities in several different academic areas, claiming highly generalisable positive results of his research on the use of portfolio assessment on his own students in teacher education (p. 735); S. Winter (1996) [the initial S is added to distinguish S. Winter from R. Winter, who is cited in a later part of my thesis] also used cooperative learning successfully in his Bachelor of Education course. These recent reports illustrated the effectiveness of innovative teaching methods in higher education and consolidated my belief that it is reasonable to try something new in my own classes, particularly when innovative approaches to teaching have been successful even when students have to use English, which is not their mother language, in learning. I can therefore trust that my student teachers, who receive their instruction in Chinese, should have little problem in adapting to an approach which allows the use of their own mother tongue.

A review of the literature indicated that the constructivist perspective of learning is accepted worldwide, and this theory could have the potential to become a framework for any viable new approach to mathematics teacher education in a

Chinese setting in Hong Kong. I first became aware of the widespread idea of constructivism during my part-time Masters study at Curtin University of Technology between 1993 and 1997. Australian educators, particularly in the last two decades, seemed to be conducting pioneering work in applying this theory of learning in mathematics and science education to address student misconceptions of mathematics and science concepts. It impressed me as a promising theory to be employed to change my students' "misconceived" beliefs about teaching. A study of the literature on mathematics education also indicated that mathematics educators (including teacher educators) have already begun to accept knowledge construction by students in an environment that facilitates discussion and construction of knowledge, however, reports on the use of constructivism in mathematics teacher education are still rare (e.g., Bauersfeld, 1995, p. 137).

Furthermore, the relationship between language and mathematics education is seemingly a common enough theme in books and articles written for mathematics teachers. In Hong Kong, current curriculum reform initiatives also employ the principle of social constructivism as a framework. The few research studies undertaken on Hong Kong Chinese student capability and flexibility in learning, mentioned earlier, suggests that students in Hong Kong can adapt to any style of learning in class, though probably they are used to direct instruction and thus expect to be taught similarly in HKIEd. Therefore, on the basis of this theory, I developed a teaching approach for the present study designed to engage student teachers in purposeful interactions among themselves and with me, their mathematics education tutor. It was anticipated that student teachers could gain a better understanding of and new insights into mathematics teaching, and at the same time, kept away from the influence of direct instruction so prevalent in my classrooms before I decided to change my teaching approach. I decided to try this out in a class of first-year Chinese student mathematics teachers in HKIEd, and to determine the efficacy of this approach through action research.

This chapter sets out the background to the thesis by first depicting the Hong Kong context, emphasising the education aspects and giving an overview of teacher education in Hong Kong. This is followed by a discussion of the aims of the study and the research questions derived from them. The broader significance of the problem in relation to the literature is then addressed, followed by an outline of the methodology. Finally, an overview of the whole thesis is provided.

BACKGROUND

The Hong Kong Context

Hong Kong, now a Special Administrative Region of China, was a colony of the United Kingdom from 1842 to 30 June 1997. After its reunification with China and under the "one nation, two systems" policy, Hong Kong enjoys its autonomy, including its education system and academic freedom, the latter of which is reinforced by the University Grants Committee (1996, pp. 13-15) – a government-appointed body advising the government on the development and funding of higher education.

Though it is a small place of less than 1100 square kilometres, Hong Kong has a population of over 6.2 million – over 95 per cent of them are of Chinese ethnicity and the rest are from a wide range of different nationalities (Census and Statistics Department, 1996, p. 22). The Chinese population originated from various provinces of mainland China, but the majority of the youngsters were born locally, where Cantonese is by far the most widely spoken language. Though the population consists mainly of Chinese, Hong Kong is a cosmopolitan city where the east meets the west and it has developed its own special features as a result of the many interacting economic, social and traditional cultural forces. Education, as part of this complex social system, has been influenced, and sometimes even driven, by the changes in and demands of the other social subsystems, the main one being the economy.

Since World War II, Hong Kong has undergone a number of significant economic changes. Following the '50s, it has been, for more than two decades, an entrêpot between the west and mainland China – owing to Hong Kong's geographical position and the political climate in the mainland. Hong Kong then developed its economy on the basis of manufacturing industry in the '60s, and attracted a substantial number of foreign investors to establish factories in the area. This change brought into Hong Kong not only technology and skills but also a massive number of immigrants from mainland China, and western cultures and ideologies. The economy of Hong Kong continued to flourish in the '70s, and after undergoing further extensive economic restructuring in the '80s, Hong Kong has established itself as an international trade and finance centre (Education Commission, 2000, p. 2).

For a long time, Hong Kong has been embracing eastern and western cultures, but at the same time it has also developed its own unique characteristics – a product of modernism, colonialism and Chinese traditionalism. Western culture, modernisation and new technological advances have affected the lifestyle and thinking of Hong Kong people, leading to a heavy emphasis on values which are commonly perceived as materialistic and consumerist, while the traditional Chinese values, which are rooted in Confucianism, are being diminished bit by bit (Lau & Yeung, 1996, p. 39). In the new millennium, traditional Chinese culture will probably be modified over and over again in Hong Kong to meet a fast-changing technological era. However, one thing is certain: a "firmly established … [fact] is our students' ability to understand and work readily in both eastern and western cultures" (University Grants Committee, 1996, p. v).

Curriculum Innovations in Hong Kong

Probably as a result of its historical linkage with the United Kingdom, Hong Kong's education system has been influenced by western philosophy, psychology and educational ideas over the years. This phenomenon is reflected in the development both in teacher education programmes and the school curricula. Similarly to many other places in the developed world, Hong Kong has seen the intensification of curriculum reform during the last 25 years. The following are some examples.

In 1972, the Education Department, under the Hong Kong government, initiated the implementation of the Activity Approach in primary schools. This approach advocates child-centred learning, and encourages the use of different kinds of teaching-learning processes – such as group activities and hands-on experience – and the use of themes in organising the curriculum. According to the Curriculum Development Council (1994) – a free-standing committee to advise the government through the Director of Education on curriculum development – the introduction of the Activity Approach has been influenced, in general, by the "progressive education" movement in the west, and its rationale is based on Piaget's developmental stage theory, Vygotsky's socio-cultural theory and Bruner's discovery learning (p. 2, pp. 6-9).

Another major innovation in the primary sector, introduced in the early '90s, was the Target Oriented Curriculum, the underlying framework of which is the social construction of knowledge (Clark, Scarino, & Brownell, 1994, pp. 14-17). It was piloted in 1995 and then fully implemented in the three major subjects in the primary curriculum, namely, Chinese Language, English Language and Mathematics.

In the secondary sector, there has not been any large-scale cross-curricular innovations similar to the Activity Approach or to the Target Oriented Curriculum, although various curriculum changes have taken place over the last two decades. These included the introduction of new subjects such as Liberal Studies, Computer Studies, and Government and Public Affairs; changes in teaching approaches such as the use of communicative approach in teaching English, and the use of issue-based teaching in the social subjects. As for secondary mathematics, the New Mathematics Movement in the west led to the introduction of "modern mathematics" as an alternative curriculum to the "traditional mathematics", starting from the '60s. These syllabuses were later amalgamated in 1985 by the Hong Kong Government's Curriculum Development Committee to form a single mathematics syllabus for secondary schools. (A new syllabus has been introduced in September 2001).

In this 1985 syllabus, problem solving and daily life applications were emphasised, among other things, in mathematics teaching. For instance, three of the objectives stated in the syllabus were:

- To prepare students to understand everyday applications outside the classroom.
- To give more emphasis to the nature and application of mathematics.
- To introduce a general sense of the pattern and power of mathematics both as a tool and as a part of our cultural heritage. (Curriculum Development Committee, 1985, p.5)

Teachers' autonomy in the use of any teaching methodology was also highlighted in the curriculum guide:

- Teachers should regard these notes as a guide to the spirit of the syllabus rather than a set of rigid recommendations that must be followed closely. They are also encouraged to try and experiment with their own methods and approaches as they think fit. (Curriculum Development Committee, 1985, p. 8)

Acceptance with Inadequate Implementation

With the introduction of so many curriculum changes – most of which involved innovative ideas – one might have expected school teaching in Hong Kong to become pupil-centred and activity-based. In reality, however, it does not appear so. For example, it has been found that many primary schools in Hong Kong adopted the Activity Approach and the Target Oriented Curriculum, but not all of them implemented the styles of teaching, learning and assessment characterised by these innovations (Chow, Wu, Chan, Leung, & Fung, 1993; Morris, Adamson, Au, Chan, Chan, Ko, Lai, Lo, Morris, Ng, Ng, Wong, & Wong, 1996). Similarly, in mathematics classes, formal instruction using whole class teaching and the lecture mode was predominantly observed, while group work and the use of other pupil-centred activities were rare. Indeed, the teaching style of secondary mathematics teachers was described as problematic by both Brimer and Griffin (1985) and F. Leung and Wong (1996) in the Second and Third International Association for the Evaluation of Educational Achievement Mathematics Study reports respectively.

It seems, therefore, that the curriculum innovations put forward by the government have not been implemented as intended. There are several explanations. One reason for the observed formal instruction in Hong Kong classrooms may be the traditional Chinese beliefs rooted in Confucianism and held by many teachers and parents. The most obvious traditions are those that emphasise prosocial behaviours and academic achievements, and the belief that effort and diligence, but not intelligence, are the determining factors to success. Thus, many parents and teachers still play an authoritarian role in disciplining children, pushing them to work hard for academic success. Thinking likewise, many children study under great mental pressures and adopt explicit behaviours, for example, working long hours in order to achieve academic excellence. Most Hong Kong schools emphasise strict discipline and proper behaviour – order and quietness – and classroom learning is mainly teacher-centred so that the crammed examination syllabus can be finished on time. Traditional whole-class teaching seems sufficiently effective for achieving high academic results, especially if assessment is based on the reproduction of knowledge presented in class. Implementing new methodologies probably means risk taking and may lead to a lowering of academic scores and hence a feeling of guilt on the part of teachers for their pupils. The more time-consuming activities suggested in curriculum statements are, therefore, ignored by teachers.

Another reason for teachers persisting with their transmission teaching mode, despite the various curriculum changes suggested, is the existence of a very competitive education system. The competitiveness results in a high demand on teachers to help students to achieve well in public examinations, leading to an emphasis on completing the syllabus and drilling students for examinations. In an earlier study by Morris (1992, pp. 48-50), it was found that the main factor perceived by teachers as a barrier to curriculum innovation is the need to cover the examination syllabus in the time available, with a similar expectation from their pupils. This "examination-centred" (p. 117) orientation was noted by the Hong Kong Government Secretariat (1981) as a reason for the highly competitive classroom environment, and the Board of Education of Hong Kong (1997), sixteen years later, recommended teachers to downplay competitive learning, to use less excessively individualised learning and to adopt cooperative learning as far as possible (p. 67).

A third reason for the common use of the lecture method is teachers' perceptions that it is the best method in the small Hong Kong classroom (with an average floor space of 55 square metres) containing a relatively large class (an average of 35 and 40 pupils in primary and secondary, respectively). Many teachers consider it difficult to arrange innovative group-learning activities rather than whole-class teaching. The government is unlikely to change the class size, as "small changes in class size have little measurable effect on student performance; marked improvements arise only with a substantial reduction" (Board of Education, 1997, p. 64; Education Commission, 1992, p. 31); nor will the classroom capacity be increased.

Though the nature of the Chinese culture and a number of practical problems were seen to be the main factors leading to teachers not implementing innovations as they were intended, Morris (1992, pp. 21-22) emphasised that it is the top-down, highly centralised and bureaucratic process in which initiatives are put into effect by the government that results in the inadequate implementation in most cases. In Hong Kong, curriculum development is initiated by the Education Department through its subject committees, which consist of panels of a restricted number of academics and educators from schools. Accordingly, only a small proportion of school heads and teachers are involved in curriculum development. Many teachers simply perceive curriculum reforms as a change in the content of the examination syllabus, and hence the content of the textbooks, but not as altering the styles of teaching, learning and assessment. For an adequate implementation of new curriculum reforms, the related ownership and autonomy issues need to be addressed. The involvement of teachers in curriculum development (e.g., in school-based initiatives) and the use of teachers as researchers to validate the proposed school curricula are necessary steps in effective curriculum reform implementation – although the idea of leaving teachers to themselves, for some, would cast doubt on the value of any innovation.

Another explanation for the unpopularity of past curriculum innovations in Hong Kong, I believe, is the way in which inservice implementation training is conducted for teachers. The most common strategy is to organise seminars in which teachers are lectured about the characteristics of, and teaching styles associated with, any new curriculum. Simply transmitting new ideas of teaching has proved to be unsuccessful in altering teachers' beliefs, and even if many teachers accept the expounded viewpoints of teaching, it is considered that they should be given opportunities to construct their understanding of the innovations based on their own experiences and on new ideas put forward. This idea is currently reflected in the consultation document on education reform prepared by the Education Commission (2000, p. 11). (The Education Commission is an advisory body appointed by the government to give advice on the development of the Hong Kong education system.)

Teachers (and schools) are believed to be the central agents for change in the more knowledge-based dynamic world in the twenty-first century, and the change depends not only on the content of the reform, but also on the knowledge and skills of engaged teachers and their openness to change for the better. Changes in beliefs about teaching should perhaps begin with student teachers. Besides having to teach a methodology module to first-year full-time students every year, I believe that student teachers should be prepared to develop new principles of teaching and learning and be more ready to change. However, the question to be considered is: how can I prepare these student teachers at HKIEd – students who have been brought up in a competitive and overcrowded learning environment, rooted in the Chinese culture and familiar with the transmission style of teaching – to be able to meet new challenges in their careers?

The theory of social constructivism offers no particular vision about how mathematics should be taught. It is, nevertheless, receiving continuous attention in Hong Kong and is believed to be effective in informing teaching and learning. It has been emphasised in the Education Commission's Year 2000 curriculum consultation document (another top-down innovation) as a new approach to be adopted. This confirmed my earlier idea of using a constructivist approach to help my student teachers to construct their understandings of mathematics teaching. As mentioned earlier, it has been noted that Hong Kong students are flexible and are particularly adaptable to working in both the western and eastern cultures, so it was my hope and expectation that students at HKIEd would accept the new approach that I planned for this study.

Teacher Education in Hong Kong

At present, initial teacher education in Hong Kong is provided by three of the universities and HKIEd, with the latter being the main provider. The universities offer mainly post-graduate diplomas/certificates in education for university graduates who intend to take up a teaching career, while HKIEd offers a variety of programmes, namely, certificate and Bachelor of Education courses for secondary school leavers and post-graduate diplomas for university graduates.

The historical roots of HKIEd can be traced back to 1853, when the first formalised school of inservice teacher training was started (Hong Kong Institute of Education, 1998, p. 10). With increasing interest and demand in teacher education from the government and from the public, four colleges of education and an institute of language in education were founded consecutively – the first in 1939. Until 1994, these colleges were responsible for providing formal preservice and inservice teacher education certificate courses to non-graduates in Hong Kong. HKIEd was established as a result of the Education Commission's Report No. 5 (Education Commission, 1992), which recommended that the four colleges of education and the Institute of Language in Education should be amalgamated into a new unitary Institute of Education offering subdegree and degree teacher education courses (pp. 66-67). As the target student teachers of this study are those in one of the subdegree certificate courses, I will give an account of this particular certificate course only.

The preservice course that I am now teaching was developed from a similar course in the then colleges of education. Both courses are two-year full-time courses with identical entry requirements. Applicants to the course should have achieved a certain level in the Hong Kong Certificate of Education Examination (HKCEE) – a public examination held at the end of the five-year secondary education. In addition, applicants should have completed two years of education beyond the HKCEE and achieved two Advanced Level passes. There are also differences. The old course prepared qualified teachers to teach, in either the medium of English or Chinese, general subjects at the primary level (for pupils from the age of six to the age of twelve) and two elective subjects at the junior secondary level (for pupils of age from twelve to fifteen). The course at HKIEd, however, employs Chinese as the medium of instruction; graduates from this course are qualified only to teach two elective subjects at the junior secondary level.

Other than separating the training of primary and secondary teachers, HKIEd has been making other development in its course structure and design. Ever since its establishment, it has been devising a coherent preservice and inservice training strategy to cope with the changes that quality school education initiatives impose on both the school system and teachers. In striving to develop its programmes to a high quality, various restructuring and revision of previous programmes has taken place. As mentioned earlier in this chapter (pages 1-5), this has led to numerous discussions and debates among teaching staff with respect to both the contents of courses and the way they should be taught. It is this process that stimulated me to try a constructivist approach at HKIEd.

I believe that initial teacher education is paramount for quality teaching and in implementing curriculum innovations, and that the use of the theory of social constructivism in my class of Chinese non-graduate student mathematics teachers is appropriate and worthy of study. A social constructivist approach as a teaching methodology is important and innovative in my workplace, even though a major school curriculum initiative in the past – the Target Oriented Curriculum – is claimed to have a theoretical framework grounded in social constructivism. In the most recent education reform document published by the Education Commission (2000), the shift from the transmission of knowledge by teachers to the encouragement of pupils to think, question, communicate and cooperate with others for learning is strongly advocated (pp. 29-30). My student teachers are the younger generation who are believed to be adaptive and versatile in a multi-cultural environment, and expected to be prepared to teach in a place where the effects of different cultures interacting are obvious. As the theory of social constructivism seems to becoming more popular in the Hong Kong school system, the notion of introducing it at HKIEd is important.

AIMS OF THE STUDY

The present action research study has been designed to determine the efficacy of an approach based on a social constructivist framework to a methodology class in a Chinese setting. It is hoped that the success of the approach could serve as an alternative, or at least an additional method, to the lecture-style delivery of mathematics course materials in Hong Kong. I am hopeful that the result will also further inform curriculum changes.

The theory of social constructivism acknowledges that learning involves not only personal construction of knowledge based on prior experiences, but also a process of social construction through interaction among students and more importantly by way of teacher-student interaction (Goos, 1999, p. 6; Lerman, 1998, pp. 337-339; Vergnaud, 1998, pp. 238-239). In Hong Kong, I observe that student teachers experience the lecture style of teaching throughout their schooling and that they have constructed some ideas about mathematics teaching before they are enrolled in the certificate course. To verify these observations, I endeavoured to investigate student teachers' prior beliefs about mathematics teaching and to determine whether these teaching ideas differ from the models advocated by mathematics educators.

Furthermore, since social interaction is emphasised in my teaching approach, it was necessary to find out the extent to which a social environment has really been created in my classroom. In such an environment, can Hong Kong Chinese student teachers feel comfortable and confident to express themselves in front of their peers, to converse freely among themselves and with me, and to relate their own ideas about teaching to negotiated methods of teaching? I would consider the answers to these questions essential to inform the actual implementation of the approach to teaching, for if outcomes are evaluated without any knowledge of the implementation, the results will seldom provide a direction of action for improvement. If such an approach to teaching was indeed found to be appropriate for use in a class of Chinese student mathematics teachers, then what would be the implications of this result in the HKIEd Mathematics Department and in a Chinese setting in Hong Kong?

The information obtained in the present study should contribute to the literature on constructivism. A search of present ERIC records confirmed that little research has been conducted on the efficacy of a constructivist approach to teaching a methods class, particularly in a class of Chinese learners. Mathematics education research in various places is underfunded (Sullivan, Owens, & Atweh, 1996, p. 3) or under-researched (Askew & Wiliam, 1995, p. 42), and much relevant research has either been overlooked or is difficult to source (Sullivan et al., 1996, p. 5). Moreover, the value and usage of action research as a means of bringing about curriculum changes, and the employability and availability of the various instruments used in the study, cannot be overlooked.

The following points summarise the purpose of this study. It

1. Investigates whether student teachers hold entrenched methods and beliefs regarding the teaching of mathematics. It is commonly accepted that student teachers have already developed some naive beliefs about mathematics teaching, and these beliefs are considered to be difficult to change.
2. Determines whether this prior knowledge of teaching methods matches the different models of mathematics teaching at the junior secondary level (i.e., for pupils between 12 and 15 years of age).
3. Determines whether a social constructivist approach could be used to facilitate student teachers' development and articulation of their understandings of the different models of teaching by providing a social learning environment in which all participants can be engaged freely in conversation, discussion and negotiation.
4. Provides information for my colleagues in the HKIEd Mathematics Department on student teachers' prior knowledge regarding teaching, on the successes and failure of the constructivist approach in developing Chinese student teachers' understanding of the various models of mathematics teaching, and in constructing a social environment in the tutorial room.
5. Informs interested teacher educators and researchers of the value of action research in introducing changes, especially changes in teaching approaches in a Chinese setting, and the employability of the various instruments used in the action research study.

RESEARCH QUESTIONS

To achieve the aims listed in the previous section, the following research questions have been formulated:

1. How entrenched are Chinese student teachers' beliefs and practices regarding the teaching of mathematics?
2. Is the constructivist approach appropriate to use with a class of first-year preservice teachers of mathematics at the junior secondary level (i.e., for pupils between 12 and 15 years of age)?
3. Can the constructivist approach also develop a social environment in the methodology classroom?
4. What are the implications of the study regarding teaching and learning for Chinese teachers of mathematics?

Question 1 will be used to address aims 1 and 2 of the study: student teachers' prior knowledge and its relationship with the various ideas about mathematics teaching. Questions 2 and 3 will address respectively the feasibility of the social constructivist approach in teaching a class of Chinese student teachers, and whether an environment that facilitates social construction of knowledge has actually been created, while question 4 will provide further information for my colleagues in the HKIEd Mathematics Department, for teacher educators and for researchers.

SIGNIFICANCE

This section briefly presents the significance of the present study to the literature on the characteristics of Chinese students in Hong Kong and action research as a methodology. Its significance in contributing to the paucity of the literature regarding the employment of social constructivism as a learning theory in mathematics teacher education has already been discussed briefly in the previous section. A fuller account of the literature will be given in Chapter Two (pages 26-69).

The following subsection discusses the significance of the study with respect to the characteristics of Chinese students in two specific areas – the maintenance of harmony and the emphasis on education – that could have an impact on student teachers' learning in a social constructivist classroom.

Chinese Learners

The application of a constructivist approach which employs discussions and reflections to teaching a class of Chinese student teachers is significant because of the behaviour and characteristics of Chinese learners. An extensive study of Chinese behaviour indicated that Chinese students are generally reserved and submissive (e.g., Barker, Child, Gallois, Jones, & Callan, 1991, p. 80; Chan, 1999, p. 296), and hence it is anticipated that in my methodology class, student teachers' interactions among themselves and with me may not be a predominant feature.

Student teachers' lack of involvement in class discussion is possibly the result of their wanting to maintain both hierarchical and group harmony (e.g., Gao, Ting-Toomey, & Gudykunst, 1996, p. 283). In traditional Chinese society, teachers and parents are the authority figures to be respected in school and at home. Challenging a teacher and talking in class would mean disrespect for the teacher and hence disrupt harmony in the hierarchy (Gow, Balla, Kember, & Hau, 1996, p. 114). Any unsatisfactory performance in class not only disgraces the student, but also brings shame on the family – again upsetting hierarchical harmony. In my class, student teachers may perhaps avoid speaking out to maintain hierarchical harmony. Harmony in the group should also be maintained (e.g., Gao et al., 1996, p. 290). Disturbing the class in progress by talking will disturb group harmony, and criticising others in class also disrupts unity and cooperation in the group. In order to preserve good relationships among everyone in class, student teachers would prefer to keep silent.

Despite the perceived reticence and obedience in class, most Hong Kong students are thought to have developed high achievement motivation and a high regard for education (Gow, Balla, et al. 1996, pp. 111-112; Lee, 1996, p. 25). As mentioned earlier, they are also considered highly adaptable to working in any cultural setting. If encouraged, student teachers can perhaps converse freely, particularly in their mother language, among themselves and with me, a Chinese mathematics teacher educator.

This study does not aim at verifying the aforesaid significant learner characteristics of Chinese students; rather, it aims at determining if a social learning environment can be created for knowledge construction by student teachers who supposedly possess characteristics that would affect their learning in such an environment. The findings will hopefully contribute to the literature regarding Chinese student mathematics teachers' learning in a constructivist tutorial room in Hong Kong, where the east meets the west. It is also hoped that implications for such an implementation in a Chinese setting elsewhere could be inferred.

The next subsection discusses the significance of action research as a methodology to determine the efficacy of the teaching approach employed in a class of Chinese student teachers.

Action Research

Action research is significant because it is a rigorous and valid research methodology recognised not only in mathematics education research, but it is also acknowledged and accepted worldwide in educational and professional development practices across a wide variety of disciplines (e.g., Kemmis & Grundy, 1997, p. 41; Mason, 1998, p. 362; McNiff, Lomax, & Whitehead, 1996, p.2). Thus, I can have full confidence in the validity of any teaching approach whose appropriateness is determined by action research.

I find action research a workable and manageable methodology suitable for my context. Its principles are easy to understand, it can be used for a class which is chosen for convenience – this is necessary, as I can only use my own class, and can only conduct the research in my own initiation. All participants in action research are engaged in the improvement of practices in the direction of a certain educational ideal, not only among the participants themselves, but also in the situation where the change occurs and where the change mechanism is the commonly agreed reflective cycle (McNiff et al., 1996, p. 22).

In any methodology class, no two student teachers can construct the same teaching ideas at the end of a learning experience. To describe or to measure the outcome of this complex individualised experience, statistical measures which give only the norm scores of behaviour seem ineffective. Thus, the methods used to study the implementation of the teaching approach in my classroom were to be open-ended, discovery-oriented and capable of describing developmental processes holistically. Hence qualitative methods, involving observations and descriptions, were appropriate (Patton, 1990, p. 106). Furthermore, a mix of both qualitative and quantitative methods of data collection was able to give a fuller picture of the educational processes occurring in the classroom. Action research, having flexibility in the employment of any relevant data collection, has this special characteristic and could be applied to my study in order to provide a better understanding of student learning in a (constructivist) classroom.

The understanding of student teachers' learning experiences and the successful implementation of a constructivist approach could further be enhanced if I was able to observe a small group of (outstanding) student teachers particularly chosen for this purpose. This selection of a case for intensive study was significant in that it offered alternative perspectives for triangulation purposes to the action researcher and it generalised the findings to the wider population (Cohen & Manion, 1994, p. 107). It was anticipated that the present study could illustrate the employability of an information-rich case serving these two purposes.

The validity of the research could be further improved if there were opportunities for sharing the teaching experiences with others involved in the process (Van Zoest, Jones, & Thornton, 1994, p. 41). It follows that this sharing could best be done by an "expert" in the field – one of my colleagues who would sit in my lectures and provide feedback to me for consideration. This colleague observer, or a critical friend, was an important component of my professional learning as well as an important factor in triangulation. The effectiveness of a critical friend was confirmed in the present study.

The concept of educators performing an inquiry to improve or to change practices is significant in teacher education. The literature reveals that lecturers in the higher education sector, including (mathematics) teacher educators, seldom conduct the kind of action research presented in this study (e.g., Altrichter, 1997, p. 33; Diamond, 1991, p. 20; John, 1996, p. 119); rather, collaboration with teachers in schools is the commonly observed action research activity (Cooke, 1998, p. 2; Kember & Gow, 1992, p. 299). Yet there is an abundance of literature which encourages teachers as (inside) researchers to improve educational practices (e.g., Bishop, 1998, p. 39). This idea, I think, should be extended to other HKIEd lecturers and to teacher educators in general.

In summary, mathematics teacher educators are reported to have undertaken very little action research activities in improving their own practices. Documenting an action research approach for my study was therefore anticipated to add to the literature in this respect. In particular, I applied the theory of social constructivism – a western learning theory – in teaching in a place rooted in the Chinese culture, consequently there is a paucity of literature to inform such kind of practice. It was therefore appropriate and justifiable to determine its efficacy and effectiveness, before its adaptation and adoption in my future teaching, through action research. The outcome of this study will hopefully contribute to the body of literature on action research in the training of mathematics teachers in a Chinese setting.

The next section briefly describes the methodology used in the present study. A fuller account will be given in Chapter Three (pages 70-113).

METHODOLOGY

Action research involving two phases and different data collection instruments was employed to investigate the efficacy of a constructivist approach towards teaching a methodology module. Triangulation was used to improve the validity of the research, to determine whether a social constructivist learning environment had been created, and to evaluate the impact of this learning environment on student teachers' prior beliefs.

The Two Phases of the Action Research

The first phase of implementing the constructivist approach in a methodology class took place in semester 2, 1997-98, with a class of first-year student mathematics teachers in HKIEd. The focus of this first phase was on emerging issues and in documenting confirming and disconfirming evidence. Specifically, Phase I implementation aimed at achieving three goals: (1) to review and evaluate whether the module is properly taught according to a constructivist approach; (2) to review, evaluate and reformulate, where necessary, the research methods used in the actual implementation; and (3) to identify factors which affect students' and lecturer's interactions.

Phase II resembled the Phase I processes except that a different class of 30 first-year student teachers, taking the same module in the same course, but enrolling in the academic year 1998-99, were employed. Phase II represented an improvement of the Phase I teaching and research study and also provided an overall evaluation of the teaching and research process.

Data Collection

Data was collected from my first-year student teachers in two ways: from structured questionnaires, namely, Van Zoest's (1994) survey on beliefs about teaching mathematics, and a survey form based on P. C. Taylor, Fraser, and Fisher's (1997) Constructivist Learning Environment Survey (CLES). Free responses in a questionnaire, in journals and in interviews were also collected. Each of these data collection approaches provided information to verify data obtained by the others. Interpretation of the data and retrospection on the findings were by way of my own journal writing and the field notes taken during my teaching practice supervisory visits. I also discussed the findings with my critical friend who provided and shared her constructive suggestions about my created classroom environment during the implementation of the study.

Maximising Rigour in the Study

In addition to the quantitative data collected in the study, thick descriptions of observations, explanations and reflections were required, as far as possible, to add rigour to my action research (Denzin, 1989, p. 83; Guba & Lincoln, 1989, pp. 241-242; McNiff et al., 1996, p. 19; Schofield, 1993, p. 109). A profound understanding of the constructivist classroom and its impact on student teachers regarding teaching beliefs required not only an average description or a general picture, but an adequate amount of confirming and disconfirming evidence from sources, as well as a variety of perspectives from many other sources. It was anticipated that the evidence gathered could confirm evidence of my preliminary action-hypotheses, provide explanations to events that were emergent and conflicting, and hence enable further actions to be planned.

I was very much aware that data analysis is an ongoing process in action research, and that I should seek to understand what was happening from the points of view of my students, my critical friend, myself and the research literature. Moreover, all these viewpoints were tentative at a particular time and were constantly changing as other unanticipated events occurred. Thus, analysis of data by stages was planned. Analysis of data immediately after it was collected, end of lesson analysis, weekly analysis and end-of-module analysis were proper procedures to meet the ever-changing events, especially any contradictory evidence that had the potential to change future actions.

Sufficient time was allowed for data collection and reflective analyses. For instance, student teachers needed time to articulate their own teaching ideas, to negotiate new or improved practices, and to compare their own naive theories with the negotiated ones. They also needed time to understand the various instructions and items in the questionnaires, particularly when some of the questionnaires were in English (These were translated to Chinese in Phase II). The critical friend required time to observe my lessons, to formulate feedback based on these observations, and to advise and discuss with me from time to time, not to mention the time required for my own diary writing and reflection on my lessons.

Last, but not least, to maximise rigour, I attempted to present evidence as clearly as possible, carrying out my interpretations as honestly as possible, while in writing up my thesis, I was to be orderly, thorough, accurate and authentic. It was considered that this approach would assist researchers to expand their insights and meanings, and hopefully generalise their own interpretations to the wider population.

OVERVIEW OF THE THESIS

This introductory chapter has provided the background to this study, explaining why I implemented a social constructivist approach to my own teaching (pages 1-5). The chapter also outlined the educational context of Hong Kong, established the aims of the study and highlighted the research questions (pages 5-17). A discussion of the potential significance of this study and of the research methodology used concluded the chapter (pages 17-24).

Chapter Two (pages 26-69) provides a full review of the literature from which the theoretical framework of this study was developed. It reviews the theory of social constructivism and the Chinese learner characteristics that have had an influence on the implementation of the constructivist approach. The principles of action research as a methodology and related issues are also included in the literature review.

The research design and its implementation are then discussed in Chapter Three (pages 70-113), where details concerning the two phases of action research, sample details, instrumentation, analysis and interpretation methods, ways to optimise rigour and ethical issues are all provided.

The results of the two phases of the study are then reported and discussed in Chapter Four (pages 114-183) and Chapter Five (pages 184-257) respectively, and finally, the implications of the study for teaching and learning at HKIEd are discussed in Chapter Six (pages 258-296).

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

INTRODUCTION

As mentioned in the previous chapter (pages 1-5), the motivation for this study arose partly from my observations of the predominance of the lecture method used by student teachers during their teaching practice, despite having been "taught" the various pupil-centred approaches to school mathematics teaching, such as small-group discussion, guided discovery and inquiry. There was a clear need for me to seek a new approach to teaching my mathematics methodology course, with the aim of helping student teachers – not only to master the skills required for different pupil-centred teaching models, but also to genuinely consider these approaches as more appropriate for achieving the goals of mathematics learning. This chapter includes a discussion of the body of literature that gave rise to the design of a teaching approach I adopted, and a methodology to judge its appropriateness in student teachers' learning. Additionally, the chapter serves to show my awareness of the paucity of literature related and relevant to my study; to clarify where my study slots into the body of literature, and to demonstrate how my study will expand the literature and chart new waters.

Chapter Two begins by exploring the underlying reasons for student teachers' reluctance in employing the more pupil-centred teaching approaches in their classrooms (pages 27-34). The findings led me to the recognition that student teachers' practices are often guided by their previous beliefs, which may have developed long before they receive teacher training and before they join the profession. Often, these beliefs contradict what teacher educators are currently advocating, and they are so persistent that they can only be changed with much difficulty. These reports further prompted me to the view that a more viable teaching approach for my own methods class should address the issue of student-teachers' prior beliefs if my teaching was to have any impact on it.

As the constructivist view of learning acknowledges learners' prior knowledge and asserts that learners construct but do not receive their own knowledge about teaching in the learning process, it explains why my teaching appeared to have so little effect on my students. Thus, I decided to design a new teaching approach based on constructivist theory. A review of the research work underpinned by this learning theory supported my initial thinking and informed me of the characteristics of such a learning environment. The review of literature in this area forms the second section of this chapter (pages 34-47).

Teaching in Hong Kong, at almost all levels, is still rather teacher-centred (Chapter One, pages 2, 8-11), employing a transmission mode that has been partly the result of approaches to learning that are rooted in Chinese culture. The literature on the characteristics of Chinese learners in Hong Kong is reviewed in the third section of the chapter (pages 47-54), to ensure that my constructivist approach takes into account these features and is thus relevant in the Hong Kong context. As one of the aims of this research study is for my own professional development, action research has been adopted. The final section of the chapter reviews this research approach that informed me how my study should be designed and implemented (pages 54-67).

STUDENT TEACHERS' BELIEFS ABOUT TEACHING

Introduction

Initial teacher education programmes must equip teachers with theoretical understandings about pedagogical knowledge and develop their ability to apply this knowledge meaningfully in classroom situations. One of the goals of such programmes is to help student teachers relate pedagogical knowledge to practice and to foster their reasoning and development (Ebby, 2000, p. 70; Kwo, 1998, p. 13; Loughran, 1996, p. 10, 1997a, pp. 4, 8) towards some educational ideals or values (e.g., Elliot, 1997, p. 25; McNiff, Lomax, & Whitehead, 1996, p. 12). That is why Diamond (1991, p. 20) suggested that beginning teachers need to be helped to cultivate and sustain their capacity to learn from their studies as well as from their teaching. Indeed, Edwards and Hensien (1999, p.187) emphasise the need for student teachers to be aware of developing new personal theories and making changes in instructional practices over time.

Though preservice student teachers usually have no prior teaching experience, my own experience with them in these years showed that they already have many ideas about teaching. My observation is confirmed in the literature. For example, Loughran (1996, p. 14) commented that:

> Student teachers enter pre-service education with a wealth of experience as observers of teaching practice.

Similarly, other researchers (such as Bramald, Hardman, & Leat, 1995, p. 23; C. A. Brown, 1993, p. 209; Grant, 1984, p. 13; Korthagen & Kessels, 1999, p. 5; Sowder, Bezuk, & Sowder, 1993, p. 240) reported that preservice teachers possess, before they come into training, a set of teaching and learning ideas which they acquired through their several years of schooling. As these prior beliefs about mathematics learning are often incompatible with current research and reform in mathematics education (see, for example, Senger, 1999, p. 200), they often affect student teachers' development of new knowledge and understanding about teaching rather than helping them to learn more effectively. Thus, it is naive to think that I can inject new pedagogical knowledge into my student teachers through lectures, expecting them to apply it as directed. The impact of previous exposure to teaching may be even more serious in Hong Kong, where, for many years, students have been exposed to a transmission mode of teaching that is contrary to current views of mathematics learning underpinned by constructivism. It became quite clear that it would require much effort on my part to change the views of my preservice student teachers about their practice. In this respect, I decided that a thorough understanding of the characteristics of teachers' beliefs about teaching and a review of teaching approaches frequently used by teacher educators would inform me of the way forward.

Characteristics of Student Teachers' Beliefs

Prospective teachers have well-developed beliefs about teaching and learning that can form obstacles to their own learning (Joram & Gabriele, 1998, p. 175). Although student teachers might not be able to verbalise their existing ideas about teaching (Grant, 1984, p. 13), these beliefs and assumptions are very often manifested in their informal conversation, in their writing and in their behaviour during the lectures and teaching practices (Borko & Putnam, 1995, p. 59; Tillema, 1997a, pp. 209-210). Often, such beliefs about teaching are so deeply implanted in their minds and are difficult to change that the impact of the teacher education programmes on them is minimal (Borko & Putnam, 1995, p. 60).

Foss and Kleinsasser (1996) found that "preservice teachers [of mathematics or of other subjects] generally remain unchanged by preservice training programs" (pp. 431, 439-440; see also Fosnot, 1989, p. 9; McDiarmid, 1990, p. 18). Moreover, changes in ways of teaching, if they ever occurred, were slow and difficult (e.g., Ebby, 2000, p. 70; Edwards & Hensien, 1999, p. 204; Foss & Kleinsasser, 1996, p. 439). Indeed, there are many reports in the literature of the lack of impact of mathematics teacher education programmes on student teachers' beliefs about teaching and learning (Ebby, 2000, p. 70; see also Klein, 1998, p. 75).

What are the beliefs about teaching held by student teachers? The literature documents that preservice teachers initially believe that teaching is concerned only with telling and showing students what to do (e.g., Berry & Sharp, 1999, p. 27; Hoban, 1997, p. 145; McDiarmid, 1990, pp. 12-13). This belief in the use of direct instruction is not in conformity with present views of mathematics teaching (e.g., Borko & Putnam, 1995, p. 58). It is, therefore, the responsibility of teacher educators to develop more appropriate teaching methods with their student teachers. However, attempts to introduce new teaching approaches, such as a constructivist approach, were found to be frequently rejected or only slowly adopted by these teachers. Van Zoest, Jones, and Thornton (1994, p. 37) explained that this could be a result of teachers' own experience with the traditional teacher-directed mathematics teaching approach – which emphasised knowledge transmission (Berry & Sharp, 1999, p. 27), drills and memorisation (e.g., Ebby, 2000, p. 69; Foss & Kleinsasser, 1996, p. 440; McDiarmid, 1990, p. 13) – throughout their previous years of schooling.

According to Borko and Putnam (1995, p. 59), other research studies in the domain of mathematics teaching showed that teachers' persistent knowledge and beliefs do affect how they understand recommended new practices and activities, and how they interpret their changes in teaching practices. This idea was also reinforced by other researchers (e.g., Confrey, 1990, p. 111; Edwards & Hensien, 1999, p. 189; Foss & Kleinsasser, 1996, pp. 430-431; Hoban, 1997, p. 133). Student teachers are inclined to teach in the way they had been taught throughout their schooling (Fosnot, 1989, p. 9; see also Ebby, 2000, p. 69; Korthagen & Kessels, 1999, p. 5), because they were deeply affected by their teachers' instructions. Any newly introduced practices can be understood through student teachers' own experiences, and these understandings determine how they actually apply these methods, or instructional tools, in the classrooms (Borko & Putnam, 1995, pp. 59-60).

A significant body of research has already pointed out that even if teachers know the relevant teaching method, they do not always use it in the classroom (Börger & Tillema, 1993, p. 185; Ebby, 2000, p. 93; Klein, 1997b, p. 290; Van Zoest et al., 1994, p. 37). Klein (1997a, pp. 66-67; 1998, p. 77) explained that this is because student teachers have a strong desire to teach mathematics as they experienced it at school, and this desire was so firmly entrenched in them that it was a part of them that could not be removed. Preservice teachers indeed appear to ignore the general philosophical disposition of the course they are taking and rely mainly on knowledge from the past (Foss & Kleinsasser, 1996, p. 439; see also McDiarmid, 1990, p. 12).

Edwards and Hensien (1999, p. 189) believed that while student teachers' beliefs affect their classroom practices, the latter could affect their beliefs in return. Thus both teachers' beliefs and their instructional practices tended to have a mutual influence on each other – a complex, dynamic, interactive and cyclic relationship, therefore existed (Edwards & Hensien, 1999, p. 189). The influence of prior beliefs was further complicated, as there is evidence that student teachers' actions might not always correspond to stated beliefs (Van Zoest et al., 1994, p.42). This instability in stated beliefs makes it difficult for researchers to identify what these beliefs are, and so to find ways of changing them will be even more difficult. For instance, during teaching practice, preservice mathematics teachers might have difficulties in implementing their stated beliefs (Van Zoest et al., 1994, p. 42). Teachers have been known to contradict the ideas of student-centred learning too (Artzt, 1999, p. 148). After the teaching practice, participants in Nettle's (1998) study took on "traditional, custodial beliefs", which were rather contradictory to the humanistic, open and reflective approaches presented in the coursework before the practicum (p. 201). It seemed that the only reliable test of changes in belief was what prospective teachers did in their classrooms, though belief changes could perhaps be inferred from a discussion with teachers of the views and understandings held by them (McDiarmid, 1990, pp. 16-17). It was indeed difficult to assess belief changes (Schifter & Simon, 1992, p. 191). Nettle (1998) suggested that further exploration on factors concerning, for instance, student teachers' previous knowledge and field experiences which influence belief change and stability, is needed (pp. 200, 202).

From the above research findings, it is clear that complex prior beliefs about teaching, which often deviated from innovative approaches to teaching, did exist in student teachers and were difficult to change. This suggested to me that I should consider the question as to whether teacher educators, such as myself, are using an appropriate approach in teaching their teacher education programmes. In this way, I believed that I could make a contribution to this field of endeavour.

Teaching Approaches Used by Teacher Educators

Until recently, there has been little progress in the collective understanding of the pedagogy unique to initial teacher education (Loughran, 1997a, p. 4). The paucity of existing research about how teachers are prepared (Cooke, 1998, p. 3; Diamond, 1991, p. 20) means that there is little information about teacher educators' beliefs, practices and pedagogical thinking. Recent studies of teacher education systems fail to explicitly mention concrete teaching approaches used by teacher educators. For instance, Morris and Williamson (1998) perceived no concrete strategies in teaching teachers in five East Asian societies – Taiwan, Japan, Hong Kong, Singapore and mainland China.

A similar situation is true in mathematics teacher education. Cooney (1994, as cited in Artzt, 1999, p. 143), in discussing the future directions of research on teacher education, acknowledged the challenges in the preparation of future mathematics teachers and questioned the types of experiences preservice teachers would need in order to become effective mathematics teachers. In a more recent publication, Cooney (2000, p. 2) further questioned the kind of theoretical constructs that could guide efforts in searching for pedagogies in mathematics and teacher education. Indeed, as pointed out by Nettle (1998),

> Within the emerging research literature concerned with student teachers' professional growth there is an opportunity to explore the ways in which teachers are taught, and thereby achieve a better understanding of the processes and outcomes of teacher education. (p. 193)

As regards teaching methods used in teaching student mathematics teachers, there was no one exemplar model of teaching that emerged in the research literature (Borko & Putnam, 1995, p. 35; Morris & Williamson, 1998, p. 26; Tillema, 1997b, p. 283), nor was there any one single cognitive psychological perspective on teachers and on teaching that could inform practice in teacher education (Borko & Putnam, 1995, p. 35). A variety of approaches to teaching teachers have been proposed, but

> Relatively few models or methods have been put forward that can help student teachers to become aware of, knowledgeable about, and actively involved in changing and (re)constructing their own teaching beliefs. (Tillema, 1997b, p. 283)

Other studies (e.g., Waugh & Waugh, 1999, p. 35) revealed that teacher educators still rely heavily on the use of the traditional transmission model, that is, the lecture method, in teaching student teachers. Samaras and Gismondi (1998, p. 716) commented that participatory classrooms, social negotiation, and interaction are all uncommon practices in teacher education classrooms. Simon (1994, p. 73) suggested that the format of traditional instruction in school mathematics has a close resemblance to teaching in mathematics methods classes. Furthermore, researchers such as Confrey (1990, p. 107), Simon (1994, p. 79) and Wood (1995, p. 331) described the procedures commonly observed in mathematics teaching classes as: an introductory review or checking of the previous day's work, development by teacher presentation on new abstract concepts to be learnt, guided practice for students and a period of independent practice.

Loughran (1996, p. 15) criticised the use of the lecture method by teacher educators as a way to avoid exploring with student teachers the various unpredictable phenomena occurring in classrooms in schools, and Elliott (1991, p. 104) considered the lecture method a technical approach to teaching. To me, the use of the lecture method by teacher educators, including mathematics teacher educators, probably explains why student teachers' prior beliefs are so difficult to change. The reason is, if student teachers still experience the traditional method of teaching in teacher education institutions, it would be very likely that they use a similar method in their own classrooms. The lecture method should be abandoned, and a new approach that can help to change student teachers' beliefs should be developed. The next section, which is a review on the theory of constructivism, shows how my study should go some way to achieve such an approach.

CONSTRUCTIVISM

Introduction

The discussion in the previous section led to the conclusion that the lecture method used by myself previously, and by many other teacher educators, is inappropriate for changing student teachers' beliefs about teaching and for helping them to adopt a teaching approach in line with current developments in mathematics learning. There are at least two reasons why lectures cannot achieve this. First, the use of the transmission method by teacher educators reinforces student teachers' views that teaching is just telling and explaining to students and hence encourages them to replicate this method in their own classrooms. Second, knowledge cannot be passed intact to the learners from their teachers (Bauersfeld, 1995, p. 140). In the case of teacher education in particular, the development and application of pedagogical knowledge and skills requires much more than understanding of concepts and theories; it requires the construction and reconstruction of personal theories and beliefs.

It is widely accepted that people commence with their own experience and knowledge in learning (e.g., Loughran, 1996, pp. 3, 5-6; 1997b, p. 63) and teachers should always start from this point also, making use of students' prior knowledge and experience to develop new understanding. That is why Sowder et al. (1993), in clarifying the problems inherent in mathematics teacher education, maintained that

> Prospective teachers need to be provided with opportunities to examine their personal understandings. (p. 243)

In addition to helping learners to examine their understandings, teachers themselves must also be aware of their students' prior knowledge and perspectives about teaching. Thus, in order to help the student teachers in my class develop the appropriate pedagogical knowledge for teaching school mathematics, it was necessary that I began by determining their prior knowledge and beliefs, and then helping them examine and analyse their own understandings and beliefs before introducing them to alternative approaches to teaching. In this way, the chance of changing their beliefs about teaching would be much greater than merely explaining to them my views on mathematics teaching. The theoretical underpinning of this approach is constructivism, which provides a framework for designing teaching and learning processes in a real, complex, ever-changing and unpredictable classroom in which multiple factors – such as individual, social and cultural – are interacting. As constructivism addresses learners' prior knowledge and beliefs, it was used as the theoretical underpinning for this study.

The next subsection discusses the use of constructivism as a framework for designing pedagogy for teacher education, reviews some previous research work on mathematics teacher education which was underpinned by social constructivism, explains the characteristics of a constructivist learning environment and, finally, develops the constructivist approach which I used for this study.

Social Constructivism and Pedagogy for Teacher Education

Constructivism, as a theory of learning, asserts that people learn by actively constructing meaning rather than by receiving information (e.g., Confrey, 1990, p. 108; Hoban, 1997, p. 133; Korthagen & Kessels, 1999, p. 10). Accordingly, learning requires the building of conceptual structures through learner reflection and abstraction (von Glasersfeld, 1995, p. 14) which are active processes involving interaction between learners' existing conceptual frameworks and new information and experiences. Hence, learning is dependent upon the preconceptions that the learner brings to the educational experience and the context in which it occurs (Anderson, 1992, p. 866). Under this rationale, everyone in a learning situation would be regarded as a constructivist (Lerman, 1994, p. 3; Mousley, 1992, as cited in Malone & Ireland, 1996, p. 120). As learners are constructing their own knowledge, so "the nature of what is constructed may be different" (Simon, 1994, p. 75) among different students within the same classroom. In this sense, learning is individual: no two students would leave the class with exactly the same understanding nor would they have an identical experience (Sutton, Cafarelli, Lund, Schurdell, & Bichsel, 1996, p. 413).

The constructivist viewpoint made me realise both the need to perceive my students as cognisant individuals who develop their own meanings, theories and beliefs, and the great impact of their prior knowledge and beliefs on their current learning. Although some researchers preferred to focus on radical constructivism in a learning situation, I consider that this viewpoint is too individualistic and fails to fully account for the inherent social nature of learning, which has become widely accepted by many researchers, such as Bauersfeld (1995, p. 140), Cobb (1999, p. 135), Driver (1995, p. 392), Ernest (1995, p. 480) and Wertsch and Toma (1995, p. 159). In explaining the process of learning, Bauersfeld (1992, p. 2; 1995, pp. 137-144) highlighted the role of the social dimension in knowledge construction and the importance of social interaction in learning (see also Cobb, 1999, p. 138; Thompson, 1995, p.127). This is the social constructivist perspective of learning as an attempt to integrate both personal knowledge construction and active engagement in social and cultural practices for mathematics education (Bauersfeld, 1995, p. 137, p. 152; see also Cobb, 1999, p. 136; Thompson, 1995, pp. 127-128).

According to Cobb (1999, p. 135), the theoretical basis for the socially and culturally situated nature of mathematical activity was inspired in large measure by the work of Vygotsky, at least in the Untied States in the past decade (see also Bauersfeld, 1995, p. 140). In Australasia, there was an increase in the number of studies of mathematics classroom interactions in which individual and social construction were encompassed (Zevenbergen, Atweh, Kanes, & Cooper, 1996, p. 32; see also Malone & Ireland, 1996, p. 120). Ellerton, Clements, and Clarkson (2000, p. 63, p. 77) contended that Vygotsky's socio-cultural theory had a significant influence on the thinking of many mathematics educators in Australasia (see also Goos, 1999, p. 6).

The key notion in Vygotsky's work is that cognition is always socially mediated or influenced by others in social interaction (see, for example, Bauersfeld, 1995, p. 152; Cobb, 1999, p. 137; Ellerton et al., 2000, p. 63; Goos, 1999, pp. 5-6; Samaras & Gismondi, 1998, p. 716). That is, complex thinking will be developed when individuals are exchanging information in particular patterns which are signified as meaningful by the community that surrounds the individuals (Goos, 1999, p. 6; Martin, 1993, p. 73). According to Vygotsky, this mediation process includes the language component and the assistance offered by a teacher or a more informed peer who interacts with the learners (Goos, 1999, p. 6; Lerman, 1998, pp. 337-339; Vergnaud, 1998, pp. 238-239), and during the interactive process, internalisation occurs with the learners developing their mental constructs. In this way, learning is perceived as both a personal and a social process of knowledge construction. My preference to adopt a social constructivist perspective lies in my recognition that knowledge construction cannot be a mere personal process. Clearly, it always takes place in the presence of others who are able to influence the learners' experience and the environment in which learning is taking place.

The social constructivist view of learning has gained increasing recognition in mathematics and science education (e.g., Bauersfeld, 1995, p. 140; Hand & Treagust, 1995, p. 177; Hoban, 1997, p. 134; Malone & Taylor, 1993, p. v; Thompson, 1995, p. 123) and in teacher education (e.g., Malone & Taylor, 1993, p. v; Sutton et al., 1996, p. 413). A search of recent ERIC records indeed confirmed that constructivism, as a model for mathematics education, had been researched widely in the west – though moreso in Australasia than in the United Kingdom and in the United States. And yet, these ERIC records indicated that there had been little research conducted specifically on mathematics *teacher* education employing the constructivist viewpoint, and the literature is even rarer regarding secondary mathematics (teacher) education (Bauersfeld, 1995, p. 137; Gale, 1995, p. xii) – and nothing was detected in Hong Kong. To try out such an approach in my mathematics methods class with a group of future secondary school teachers will add significant value to the local literature. However, the success or otherwise of this tryout depends, to a large extent, on the design of the approach. This leads to the following subsection which reviews previous work based on social constructivism and from which I can draw upon.

Reported Examples in Teacher Education

Although there is little in the literature concerning the use of a constructivist approach for developing mathematics teachers, a few examples – involving either inservice or preservice teachers – were identified. These, together with two other successful examples in other areas of teacher education, provided me with some illustrations on the design of a constructivist approach and are reviewed below.

More than a decade ago, in the United States, a group of researchers, headed by Simon (1994, p. 73), implemented a large-scale training programme for inservice mathematics elementary and high school teachers, designed on the basis of social constructivism. The aim of the programme was to help them to use a social constructivist approach to teaching mathematics in schools. Among the successful reports was a case study in which the teacher involved was found to become more interested in mathematics teaching, to be able to carry out more learner-centred teaching and to analyse pupils' learning more deeply, and to form a "community of discourse" among teachers of the same school (Fosnot, 1989, p. 115). Another report by Schifter and Simon (1992) pointed out that, after training, the teachers were perceived to have developed the constructivist epistemology.

Another successful study in developing teachers through the use of a constructivist approach involved a psychology class in a Bachelor of Education course in Australia. The researcher, P. G. Taylor (1995), emphasised that student teachers in his course acquired understandings and gained confidence as they engaged in the process of articulation, clarification, justification, negotiation and reflection – which are activities typical of a social constructivist approach. The study, he reported,

> Provides strong evidence for the claim that constructivist learning theory has powerful implications for practice, and that our experiences of learning and teaching can be better understood with its assistance. (p. 207)

Chin (1997) also reported on his success in the education of secondary science preservice teachers in a methods course in Canada. The student teachers became confident, reflective and active participants in their professional development. In explaining his success, he highlighted that one of the strongest informing influences on his teacher education practice has been the constructivist view of learning (p. 121).

The work of Klein (1997a, 1997b, 1998) on over 200 Australian preservice primary school teachers in a mathematics methods class helped these student teachers gain both mathematical knowledge and confidence in teaching mathematics. However, although these student teachers appeared to have adopted the terminology and strategies of "constructivist" practice (1997b, p. 290), they seemed to have no intention and purpose to change their own epistemological beliefs about the nature of mathematics and about how mathematics should be taught. Klein reported that the "teach-as-usual" pedagogical desire was implanted in them and became a part of them that could not be removed (1997b, p. 278).

The research outlined above further supported my decision to adopt the constructivist approach for my methods class and indicated to me how I should design and implement my lessons. Though Klein was unable to change her students' prior beliefs after the course, her work informed me of the precautions that I should take in my design. To me, Klein's defeat was mainly due to her failure to genuinely implement a social constructivist approach. With a class size of over 200 students, Klein admitted that she was forced to use a lecture method, within which she encouraged students to be involved actively and to collaborate. However, such a learning environment would not facilitate student interaction and group work. Although the class size in my institution could be quite large for some core courses, my methods class usually totalled about 30 students only, so the conduct of group work was feasible and manageable. In designing my teaching, P. G. Taylor's (1995, p. 209) focus on "the development and sharing of personal theories" among students was given great consideration. His approach of providing ample opportunities for students to articulate and clarify their own theories, to justify and to negotiate these theories with those of others was adopted for my study. All these activities are vital to the development of students' own theories, and have great potential to lead to a change of their beliefs.

Two more recent examples of the use of a social constructivist approach in mathematics teacher education were noted after the implementation of my study. The one by Edwards and Hensien (1999) claimed to have successfully reformed the teaching of those teachers in the study, and another by Bolte (1999) is described as having enhanced both the teaching and professional development of the teachers. Both these studies were characterised by requiring teachers or student teachers to examine and express their beliefs about teaching, to discuss and share with each other actively, and to reflect critically – as described by Bolte, to be engaged in "mathematical discourse" (p. 167). These two reports further supported my selection of a social constructivist approach to develop student teachers' ideas about teaching methodologies.

The Social Constructivist Learning Environment

Characteristics

In applying a social constructivist teaching approach, I should assist my student teachers in constructing knowledge through learning experiences involving group work and active social interaction with a substantial use of language for negotiation and sharing. However, mere student-student interaction may not guarantee that the newly constructed ideas of mathematics teaching are what I, as a mathematics teacher educator, consider to be desirable. The inclusion of teacher-student interaction (in my context, this will mean lecturer-student interaction) in the learning process is crucial (Lerman, 1998, pp. 337-339; Vergnaud, 1998, pp. 238-239). This need to involve both types of interactions has been confirmed by Bauersfeld (1995, p. 153, p. 158; see also Cobb, 1999, p. 139).

In interacting with my students, my role in a social constructivist environment should be that of an expert – as recommended by Confrey (1990, pp. 111-112). I should act as "[a] mediator ... of students' encounters with their social and physical world and as [a] facilitator ... of students' interpretations and reconceptualizations" (P. C. Taylor, Fraser, & Fisher, 1997, p. 295). My role as a mediator is crucial, because, according to Vygotsky, mediation is the significant process leading to learning (Lerman, 1998, pp. 337-339; Vergnaud, 1998, pp. 238-239). This means that I have to create situations and organise activities in assisting my students to construct pedagogical knowledge. Once the learning environment has been established, I should facilitate student teachers' constructing and reconstructing new understandings by, for example:

- monitoring the learning situation;
- helping students to select and to identify relevant information in their discussions; and
- guiding students to infer from the results of their discussions.

In addition, I should also be a good listener, as suggested by von Glasersfeld (1995, p. 14), because it is only through careful listening to their views that I could understand their thinking, provide them with appropriate feedback, and learn more of their beliefs about mathematics teaching.

In researching on the nature of a social constructivist learning environment, P. C. Taylor et al. (1997) developed an instrument – the Constructivist Learning

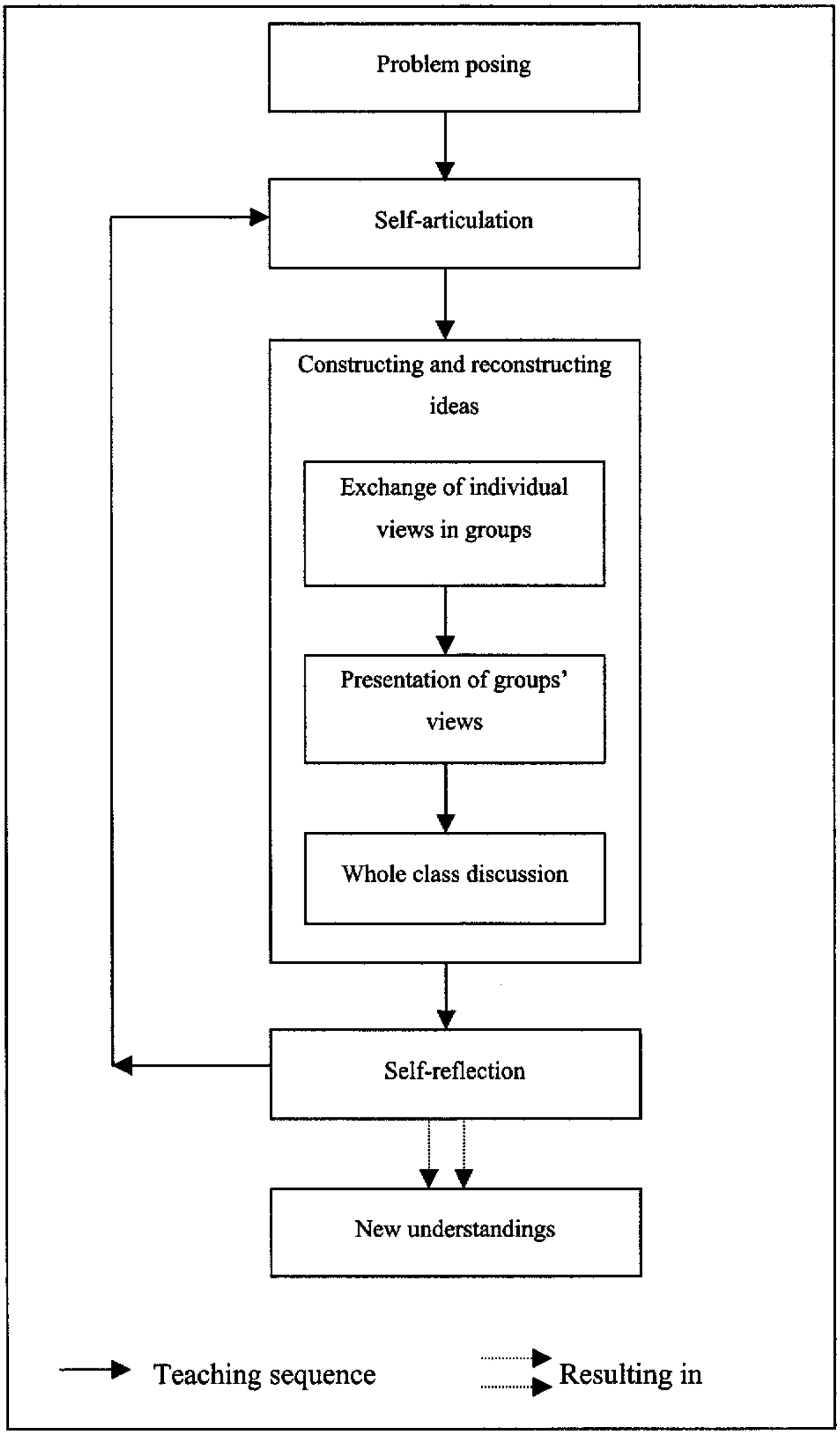
Environment Survey (CLES) – for researchers and teachers to monitor the development of constructivist approaches to teaching science and mathematics classes. The CLES included five important parameters delineating the characteristics of a social constructivist learning environment, which provided me with further guidance in planning my approach for this study. The parameters are:

- Personal relevance, which means that students' experiences should be used as a meaningful context for the development of knowledge.
- Uncertainty, which means that there should be opportunities for students to experience knowledge as evolving, non-foundational, and culturally and socially affected.
- Critical voices, which means that students can express their concerns about their learning and even question the teacher's pedagogical plans and methods.
- Shared control, in which students are invited to share with the teacher control of the learning environment.
- Student negotiation, in which students are encouraged to explain and justify their ideas, listen to and reflect on others' ideas, and critically reflect on their own.

The Social Constructivist Approach for This Study

On the basis of the literature I reviewed concerning the rationale underlying social constructivism, the features of successful practices by previous researchers, and the characteristics of a social constructivist learning environment illustrated in the CLES, I developed a four-stage social constructivist teaching model (adapted from Driver and Oldham's constructivist teaching sequence, 1986, p. 119 and is represented in Figure 2.1). I believed that successful implementation of this model of teaching, which was designed on a recognised (social constructivist) learning theory, would be significant as both concrete models and learning theories relating to the preparation of secondary mathematics teachers were rarely reported in the literature.

Figure 2.1
My Social Constructivist Teaching Model, Consisting of Four Stages (adapted from Driver & Oldham, 1986, p. 119)



My rationale for the four stages of my social constructivist model was as follows:

1. Problem posing

   This involved the posing of a problem concerning the teaching of a topic in school mathematics to student teachers. The problem set the agenda for what student teachers would learn. The stage was important because the problem itself would have personal relevance to the student teachers in their preparation to become a teacher. Having personal relevance had great significance, as it ensured that there was a meaningful context for developing knowledge (see the first parameter in the CLES, page 42).

2. Self-articulation

   Student teachers would be asked to consider the problem individually and to write down the solution. This stage provided an opportunity for individuals to examine their prior knowledge and beliefs about teaching. The recording of their suggested solutions helped them to elicit their ideas explicitly, leading to a more in-depth self-examination of teaching ideas.

3. Constructing and reconstructing ideas

   This is the main stage where students were assisted to construct new knowledge and understandings. It included a number of steps, the first of which was to let students recognise the inadequacy of their previous approaches. This step was necessary because, according to von Glasersfeld (1995, p. 15), if learners were led to see that their own approaches to solving problems or interpreting phenomena was inadequate, then they had the incentive to change their approaches. Other researchers (such as Borko & Putnam, 1995, p. 53; Chin, 1997, p. 121; Confrey, 1990, p. 112; Jaworski, 1994, p. 230; Loughran, 1997b, p. 57; Nicol, 1997, p. 97) also suggested that lecturers should identify student teachers' conceptual structures, and lead them to find out whether their approaches to the problem were adequate or not.

Student teachers were formed into groups to discuss the solution which each of them had written down. In their discussion, they could question one another on the feasibility of each approach and the underlying rationale. The realisation that their own teaching approach was inadequate could compel them to search for more viable approaches by reconsidering their own constructs and those of their peers. However, in the process, I needed to be aware of Confrey's (1990, p. 112) point that students themselves should decide whether their own constructs were adequate or inadequate – not me. Otherwise, students would have no incentive to search for a more workable solution. As students worked in groups, individual problems would become a group problem, and everyone in the group should be highly motivated to undertake further sharing and negotiation, hopefully to reach a final optimal solution.

Next, individual groups were asked to present to the whole class the solution each has agreed upon. This provided further opportunities for new challenges posed by other student teachers and myself as well. This was then followed by a whole-class discussion (either led by a student teacher or myself) in which student teachers extended their discussion by sharing and negotiating ideas. The significance of the interactive process is that, in expressing themselves and interpreting others' views, students develop personal understandings of mathematics teaching and become increasingly sensitive to the beliefs and values of others. In addition, by being exposed to more varied ideas, individual student teachers will be motivated to re-examine and reconstruct their personal understandings. Presenting them with opportunities to point out the inadequacy of one another's existing understandings and seek for more viable knowledge, this third stage not only encouraged student discussion and negotiation, but also allowed them to recognise that knowledge is evolving – thus meeting the "uncertainty" criterion of the CLES.

4. Self-reflection

After the interaction and discussion in the previous stages, student teachers were given a chance to undertake self-reflection which helped them to clarify and to rethink their own views and beliefs in the light of those of others. This stage was particularly important in allowing them to systematically modify their own cognitive structure, making the previous activities meaningful. They were also asked to undertake self-articulation again by rewriting their newly developed approach to solve the problem posed by me at the beginning of the activity.

In implementing the social constructivist teaching approach in my methods class, as well as adhering to the teaching sequence explained above, I also strove to ensure that two other parameters described in the CLES were included. They were: "critical voices" and "shared control". This meant that I was to set up a non-threatening and open atmosphere, encouraging my students to express their views about my plans and methods and my way of organising the activities. I was also to provide them with opportunities to control learning; for example, they should be encouraged to suggest problems for discussion and to modify learning goals to be achieved. If, after the construction of the new learning approach, the student teachers' chosen method did not coincide with mine, I was to consider revising my own beliefs and negotiating with them for mutually acceptable alternatives.

The use of activities, such as discussions and group work, does not automatically ensure successful knowledge construction (Anthony, 1996, p. 349); to me, it also depends on students' willingness and ability to learn in a different way. Bauersfeld (1995) also maintains that the success of generating viable constructions not only depends on the qualities of the social interactions, but also on the participants' active engagement in the social practice (p. 152). However, not all student teachers are comfortable in discussing views in public, and they may also find it difficult to articulate their beliefs about teaching in writing. This realisation led to a thorough review of the characteristics of my learners described in the next section, and consequently, my study extends the literature to include insights into the training of Chinese mathematics teachers in Hong Kong.

CHINESE LEARNERS

Introduction

The application of a constructivist approach to teaching my class of Chinese student teachers is significant because of the interesting perceptions of Chinese learners' classroom performance and behaviour then become apparent. Chinese students are perceived to be quiet and receptive, and hence very little interactions among students and between lecturer and students could be anticipated in the usual tutorial rooms. I considered it therefore doubtful whether the learning style of Hong Kong Chinese student mathematics teachers could cope with a constructivist approach which I intended to implement – an approach that required a willingness to expose one's own ideas to query and to open discussion. Efforts were to be made to fully understand Chinese thinking that influences typical classroom behaviour before attempting to design an appropriate teacher education programme (Chan, 1999, p. 295). Consequently, crucial factors, such as classroom communication patterns and motivation to learning, that could contribute to the success of a constructivist teaching approach and that characterise Hong Kong students (whose attitudes are rooted in the Confucian heritage culture) are reviewed in the following subsections. In particular, two specific Chinese beliefs – the need to maintain both hierarchical and group harmony and the emphasis on education for personal development and for social mobility – are discussed. The former belief affects students' classroom communication patterns and the latter, their motivation to learn.

Maintaining Hierarchical and Group Harmony

There is ample anecdotal evidence that Chinese students, in Hong Kong and elsewhere, are usually quiet and obedient (e.g., Barker, Child, Gallois, Jones, & Callan, 1991, p. 80; Chan, 1999, p. 296; Gow, Balla, Kember, & Hau, 1996, p. 109; Jin & Cortazzi, 1998, p. 752; Sue & Okazaki, 1990, p. 915). Barker et al. (1991) reported that Chinese students in Australia "adopt passive learning styles and avoid debate or criticism of the materials raised in class", and they seemed to "lack ... experience in small group teaching and interactive learning styles" (p. 80). Similar observations have been reported in Hong Kong (e.g., Gabrenya & Hwang, 1996, p. 314; Goodwin & Tang, 1996, pp. 301-302; Gow, Kember, & McKay, 1996, p. 243; S. Winter, 1995, p. 35), with Pratt, Kelly, and Wong (1999) even criticising Hong Kong Chinese university students as taking "a quiet, receptive, and deferential attitude during class, and lack of challenge or questioning of the authority of the text or teacher" (p. 250).

The observed silence among Chinese students in class may, perhaps, be interpreted by some people as an indication of their passivity to learning. However, I agree more with the views of those researchers (such as Chan, 1999, pp. 297-298; Gao, Ting-Toomey, & Gudykunst, 1996, p. 283) who suggest that the lack of interactions among Chinese students and questioning of their teachers in classrooms is very likely a result of their belief in the importance of maintaining harmonious relationships, both in the group and in the hierarchy – for harmony is the foundation of Chinese culture.

The Impact of Harmony on Class Interactions

Growing up in the Chinese culture, students adopt the belief that by preserving peace and unity in class, they would create "an amicable climate for future cooperation and negotiation" (Gao et al., 1996, p. 291). They are also aware that true opinions, once expressed, would very likely embarrass and offend others (Chan, 1999, p. 299). Often, the concern for what others would say and the fear of being criticised and ridiculed by others cast an unbearable pressure on a Chinese student (Gao et al., 1996, p. 290). Consequently, some may strive to change their behaviour to fit in with others (in class) in order to avoid criticism and win approval (Chan, 1999, p. 298; Goodwin & Tang, 1996, p. 302; Jin & Cortazzi, 1998, pp. 752-753; K. Leung, 1996, p. 258). Such behaviour and beliefs are demonstrated by my student teachers at HKIEd and, upon reflection, by myself also when I was a student.

Students may refrain from speaking out in front of the class because of the student-student group relationship characteristics of the Chinese culture. Such assertions are perceived as interrupting others and even wasting time in the lesson (Pratt et al., 1999, p. 255; see also Jin & Cortazzi, 1998, pp. 752-753). They would not like to criticise another student, fearing that this may lead to conflict, dispute and confusion, and consequently direct confrontation and upsetting "the harmonious fabric of personal relationships" (Gao et al., 1996, p. 290). Students also try to avoid showing their competence in class; they prefer to remain humble and polite in order to maintain self-effacement, group harmony and cooperation (Hau & Salili, 1996, p. 132; see also Chan, 1999, p. 299; Gao et al., 1996, p. 287; K. Leung, 1996, p. 251; Yu, 1996, p. 233).

Chinese are more likely to become involved in conversations with someone they know; they rarely speak to strangers, because they do not feel comfortable or knowledgeable in dealing with strangers (Chan, 1999, p. 299; Gao et al., 1996, p. 288). If my students are unfamiliar with one another (or not "friends"), class discussion will become difficult. However, the student teachers in my class were all taking the same elective subject and had already been in the same class for other modules in semester one. They were familiar with one another, though the extent to which they were "friends" varied. But the question as to how I could encourage them to share their views, to question one another and to present alternative suggestions openly without any negative feeling remained.

Stevenson and Lee (1996, p. 134) pointed out that Chinese pupils magnify success and failure through the "individuals' identification with their families and the larger society" rather than through a simple desire for self-advancement and recognition, and that failing to perform well in school not only result in a loss of status of the individual, but a far more critical loss of family prestige. Yu (1996) suggested that, at its worst, students may develop undesirable personal traits, such as a sense of shame, a lack of interest, a lack of self-confidence, self-blame and a weakened achievement motivation (pp. 244-245). This cautioned me to be alert to the fact that the student teachers in my class would feel vulnerable when asked to disclose their teaching ideas for judgement and scrutiny during the class meetings. If their feelings have not been respected, not only would the constructivist approach fail to be implemented successfully, but a negative impact on my students would also be produced. On the contrary, successful implementation of the approach would help these student teachers construct appropriate pedagogical knowledge, and the pleasure in having open and critical discussions with peers may change their future attitudes in this respect.

While Chinese students may avoid expressing themselves among peers through wanting to maintain group harmony and preserve family prestige – a kind of hierarchical harmony – they also show great reserve in expressing themselves in front of their teachers. This is due to the existence of another superior and inferior hierarchical relationship in Chinese culture. According to Gao et al. (1996), not everyone in a Chinese community is entitled to speak freely, and those who can are recognised as having seniority, authority, experience, knowledge and expertise (p. 285). In the classroom situation, then, only the teachers have this right, because of their years of experience and education (Pratt et al., 1999, p. 246). They are the authority figures to be respected: their words are usually taken as golden principles that should not be challenged, but followed (Chan, 1999, p. 298; Gow, Balla et al., 1996, p. 114; Pratt et al., 1999, pp. 246-247), and any signs of student talking would mean – to both teachers and pupils – disrespect for the teachers' knowledge, experience and status. Jin and Cortazzi (1998) further commented that comments from other members of the class would seem inferior and untrustworthy, if not irrelevant and incorrect, and consequently, talking among peers could not result in learning (p. 744). If such is the case, students seemingly expect, and are also expected by their teachers (and parents), to be taught – a clear indication that the lecture method is preferred.

Learning by group work and class discussion is thus rare in a Hong Kong Chinese classroom (Biggs & Watkins, 1996, p. 275), and Jin and Cortazzi (1998) contended that Chinese students adopt the "learner-listening approach" (p. 74). Gao et al. (1996) reported that most Chinese schools only emphasise listening, memorising, writing and reading skills, but rarely give importance to speaking skills (p. 286). In this way, students have little chance to develop the ability to express themselves, and indeed, Hong Kong students show the tendency "to have good receptive skills, listening and reading, but poor expressive skills, speaking and writing" (Biggs & Watkins, 1996, p. 278). My students in this study were most probably used to listening rather than speaking in class.

Although the characteristics of student teachers in my study – namely, lacking experience in group discussion, and avoiding both self-expression in public and questioning the teacher – appeared to discourage the implementation of my constructivist approach, I believed that student teachers' respect for the teacher as an expert may, to some extent, have favoured it. Though highly student-centred, the constructivist approach required me to play an expert role, as both mediator and facilitator. Student teachers would follow the instructions of the facilitator, and, in the event of a disagreement in a class or group discussion, with no consensus emerging, my role as a mediator – a respected elder in this case (Gabrenya & Hwang, 1996, p. 318; Gao et al., 1996, pp. 288, 292) would be much appreciated by the students.

Overall then, the student teachers in my study, as typical Chinese students in Hong Kong, were likely to be quiet and receptive in my methodology class. Probably, they were used to listening more than speaking, and they may have lacked self-articulation and interpersonal skills, which are considered prerequisites to constructivist learning. Student teachers were also seemingly afraid of asserting themselves in front of me, the lecturer, and not willing to disrupt the lecturer-student hierarchical harmony. Moreover, they had been nurtured to be modest, effacing and not judging in order to avoid hurting other people's feelings, thereby maintaining the harmonious friend-friend group relationship. They may also have been concerned that by disclosing themselves, they may have demonstrated their weakness in front of a class, which could mean a disgrace to oneself and to the family. All these characteristics were identified in the literature, and to some extent detected by me in my previous experience. They appeared to discourage the use of a constructivist approach. However, despite this, there have been reports on the successful use of innovative teaching strategies in tertiary institutions as mentioned in Chapter One (page 3) – albeit not the constructivist approach. The success of the approaches has been attributed to students' high achievement motivation and their adaptiveness to the learning situation as a result of their belief in education as the long-recognised and respected means of personal, social and economic advancement (Pratt et al., 1999, p. 254). Achievement motivation among Chinese students is reviewed in the following subsection.

Achievement Motivation

High achievement motivation and the drive to outperform one's peers are probably the result of the emphasis on education among Chinese learners (Biggs, 1995, p. 88). Lee (1996) claimed that the fundamental value of education seems to lie in the perfection of the individual, but the possibility of upward social mobility is also important, for it develops fame and glorifies the family (pp. 37-38; see also, for example, Biggs, 1995, p. 89; Chen, Lee, & Stevenson, 1996, p. 83; Cheng, 1997, p. 37; Gow, Balla et al., 1996, p. 112; Pratt et al., 1999, p. 250; Stevenson & Lee, 1996, p. 134; Sue & Okazaki, 1990, p. 915; Yu, 1996, p. 234). The duty to pursue this kind of individual success is considered by Biggs (1995, p. 89) to be a particularly powerful motivating stimulus. Hong Kong students have already demonstrated their high levels of achievement, for instance, in mathematics and in reading (e.g., Biggs, 1996, p. 150; Chen et al., 1996, p. 88; Stevenson & Lee, 1996, p. 129).

To achieve academic success, Hong Kong Chinese students believe that effort and time, but not intelligence, are needed (e.g., Biggs & Watkins, 1996, p. 275; Hau & Salili, 1996, p. 129), and consequently, they are reported to be diligent and to spend large amounts of time on academic pursuits (e.g., Lee, 1996, p. 25; Pratt et al., 1999, p. 255; Stevenson & Lee, 1996, pp. 132-133). Driven by a need to perform well in whatever tasks set, these students are highly motivated and are alert for cues that could help them do so (Biggs & Watkins, 1996, p. 273). They are considered keen and competitive (Gow, Kember, & McKay, 1996, p. 243), and coupled with "a high disposition to learning" (Chan, 1999, p. 296), they foster a sense of diligence, responsibility and receptiveness – the last of which refers to students' willingness to follow the teachers' guidance. Preservice Chinese mathematics teachers in the present study, who are also Hong Kong students, most certainly would have inherited traditional Chinese values with regard to education, and exhibit the above characteristics.

While there is no reason to assume that student teachers of HKIEd are atypical among Hong Kong tertiary students, I would assert that they would be able to adapt to different teaching methods because of their high achievement motivation and eagerness to learn. My students were active learners – a prerequisite for effective learning in a constructivist classroom – and as long as I was aware of (1) student teachers' respect for harmony in the hierarchy and in the group, (2) their long-time immersion in a didactic teaching environment, (3) their feelings and reactions in my class, and (4) the period of time required for knowledge construction, I was sure that constructivist learning could be facilitated. The practicality of my constructivist teaching, including the precautions to take in a class of Chinese learners, will be described more fully in Chapter Three (pages 79-86, 101-108).

Though a large number of research findings have been gathered on Chinese culture and learning over the last three decades (Bond, 1996, p. xviii; K. Leung, 1996, p. 247), further investigation is required. Information on the use of innovative strategies in teacher education courses in Hong Kong is rarely seen. Most research has been conducted in the universities, and none of it has been on the implementation of a constructivist approach. My study adds to the literature an exploration of the feasibility of using such an approach with non-graduate student teachers and the influence of this style of teaching on these students. In conjunction with future studies of innovative approaches in educating Chinese learners, issues of harmony maintenance, student perception of their own role and status in class, of open discussion and of negotiation should be further explored.

ACTION RESEARCH

Introduction

In recent years, action research, the "50-year-old methodology" (Watt & Watt, 1999, p. 49), has received a widespread acceptance and has created a growing interest in educational and staff development practices across a wider range of subject areas (e.g., Altrichter, 1997, p. 29; Kemmis & Grundy, 1997, p. 41; Mason, 1998, p. 362; McNiff et al., 1996, p. 2; Melrose, 1996, p. 53; Watt & Watt, 1999, p. 49; Webb, 1996, p. 148) than "most other methods in the social sciences" (Cohen & Manion, 1994, p. 186). The prominence given to action research is due to its potential in transforming teaching practices for the individual teacher or even for the individual school (e.g., Leder, 1998, p. 132; Wiliam, 1998, p.12). The increasing significance given to the practice of action research is also a result of a shift of the research perspective away from the positivist paradigm. Though action research represents a different paradigm, according to Bishop (1998, p. 39) and Elliott (1997, p. 24), it does not adhere to any particular methods of data collection. There is also no widespread agreement about ways of working and the basic principles of action research (Wiliam, 1998, p. 3). Hence it often embraces the characteristics of both the positivist and the interpretive perspectives.

In addition to its dynamic and continual transformative power, action research is a unique methodology applicable to studies in mathematics teacher education. Mathematics education research, according to M. Brown (1998, p. 263), has grown into "a field of inquiry that draws eclectically on the theories and methodologies of a broad span of science, social science and the humanities". Ernest (1998) suggested that mathematics education is "more akin to the humanities and social sciences than the physical or hard sciences" (p. 73). Indeed, several authors (e.g., Adda, 1998; Ernest, 1998, Lerman, 1998, Nickson & Lerman, 1992; Sowder, 1998; Wittmann, 1998) stressed the need to take into account the specific social and institutional contexts that affect the teaching and learning of mathematics in schools and the growth of mathematical knowledge, and rejected the objective Platonic attitude held by some mathematicians. Mason (1998) also believed that one of the most significant developments in mathematics education research in the past decade was the active and continuing exploration of, and work on, teachers' and lecturers' own practice (p. 359).

Despite the growing trend in using action research for educational inquiry and the emphasis on investigating phenomena in a single educational setting in mathematics education research, a recent ERIC search revealed few mathematics *teacher educator*'s reports on action research. The same was true when I reviewed the literature. For example, in the *Journal of Mathematics Teacher Education* – a new journal in print since 1998, I found only one article (Edwards & Hensien, 1999) which described a collaborative action research between a middle school mathematics teacher and a mathematics teacher educator. The most frequently addressed issue in the journal, according to Wiegel (2001, p. 173), is teachers' mathematical knowledge, but not the development of a mathematics educator. Indeed, Tzur (2001, p. 259) discovered few studies that focused on developing mathematics teacher educators. Using an action research approach for my study will, therefore, add to the literature in this aspect of mathematics teacher education research.

The following subsection reviews the characteristics of action research and the rationale underlying my choice of this methodology.

What is Action Research?

There seem to be different interpretations of action research (e.g., McNiff et al., 1996, p. 9). Rearick and Feldman (1999), after reviewing the international literature on action research in teacher education, identified numerous models of action research which are grouped either with respect to their differences in theoretical orientations, purposes and products, or according to the relationships among the research participants (which could be teachers, teacher educators, school administrators or parents) (pp. 333-334). Marsh (1997, pp. 167-168) found that action research is an umbrella term used by researchers to encompass a variety of research approaches which involve participants in a particular natural setting. These research approaches all aim at developing more efficient existing practices or new ones, and operate within either personal ideals, group values and constraints, or a shared radical consciousness. It should be noted that in action research, the researcher is one of the participants.

Although the primary aim of action research is to change the researcher, often it also leads to improvement in the situation in which the researcher is in. One of the new directions in action research, according to Zuber-Skerritt (1996b), is to "chang[e] the system itself or those conditions which impede desired improvement in the system/organisation" (p. 5). Indeed, for some action researchers, their ideal is to use group effort to change institutions and society (e.g., Kemmis, 1993, p. 189; McTaggart, 1997, p. 34; Melrose, 1996, p. 52; Zuber-Skerritt, 1996a, p. 95). However, McTaggart (1997) was concerned that it is beyond the capacity of individuals to change a situation, a whole society or culture, but suggested that individuals might change themselves first, then support others in their own effort for improvement and, eventually, work together to change institutions and society. This viewpoint is supported by a number of other researchers (e.g., Melrose, 1996, p. 52; Zuber-Skerritt, 1996a, p. 95).

Improvement in practices in action research is, according to both McNiff et al. (1996, p. 22) and Webb (1996, p. 147), commonly agreed to be facilitated by the notion of a reflective cycle/spiral or "a spiral of self-reflection" – a spiral of cycles of planning, acting, observing and reflecting – as stated in Kemmis' (1993, p. 184) interpretation of Lewin. Committed researchers, as participants, will define the value or ideal into concrete forms of action or action-hypotheses for the particular circumstances, reflect on their practices in terms of the ideal and knowledge of the specific situations, and then modify their practices for the better in the light of these reflections (Cohen & Manion, 1994, p. 192; Elliott, 1991, pp. 49-50; Hammersley, 1993, p. 212; McNiff et al., 1996, pp. 12-13).

Furthermore, since values, behaviour and knowledge produced before, during and after the action are always tentative and open to debate, continually involving oneself in self-reflecting on one's practices can further modify and refine the constructed understandings (Elliott, 1991, p. 50; McNiff et al., 1996, p. 2). When participants have sufficient confidence in their action-hypotheses, they will allow these hypotheses to guide their actions (Elliott, 1997, p. 74). Hence, by means of the continual reflection on practices or the reflective cycle, all the modifications – immediate, short term or ongoing – for a particular setting are well informed (and committed) (McNiff et al., 1996, pp. 17-18). This further planning and action on emergent practice makes action research different from the other types of educational research methodology (e.g., Ernest, 1998, p. 77; Leder, 1998, p. 132; Nickson, 1992, p. 108).

In the school context, the practical attempts by teachers to become researchers of their own educational practices to improve the curriculum, the pedagogy and the school organisation may be called action research. Elliott (1997) purported that

> Action research [takes] the form of a self-reflexive experimental process in which the teacher [monitors] his or her interactions with students in determining what constituted educationally worthwhile curriculum experiences. (pp. 18-19)

As the central agents of change, the teachers, as insiders, must have a better understanding of their own situations than the other participants in the setting, and hence I think they have a greater need of disciplined inquiry in order to effect a bottom-up pedagogical aim. This reconceptualisation of the teachers' role is now described not only by "action research" – a phrase which was initially coined by Lewin around 1944 (Kemmis, 1993, p. 178) – but practitioners are also referred to as "teachers as researchers" (Malone & Taylor, 1993, p. vi; Marsh, 1997, p. 164), "teachers as curriculum developers", "teachers as facilitators of student learning", "teachers as learners" (Malone & Taylor, 1993, p. vi). The term is also used in referring to: "school-based curriculum development", "participatory decision making", "school-level evaluation", "school-based innovation" and "school-based in-service education" (Kemmis & Grundy, 1997, p. 41). The idea of teachers as researchers was adopted by me in my role as a lecturer in HKIEd. (A fuller account of lecturers as researchers will be given later in the subsection "Professional Development" of this chapter, pages 63-65.)

Overall, the striking features of action research can be summarised by Elliott's five principles of action research (1997, p. 25):

- Action research is directed towards the realisation of an educational ideal, e.g., as represented by a pedagogical aim;
- it focuses on changing practice to make it more consistent with the ideal;
- it gathers evidence [by any data collection method] of the extent to which the practice is consistent/inconsistent with the ideal and seeks explanations for inconsistencies … about the operation of contextual factors;
- it problematises some of the … theories which underpin and shape practice, e.g., taken-for-granted beliefs and norms;

- it involves practitioners in generating and testing action-hypotheses about how to effect worthwhile educational change.

Reasons for Using Action Research

Elliott's (1997, p. 25) methodological principles of action research imply that action research is an appropriate methodology which can assist in determining feasible methods of teaching by taking into consideration contextual influences in a particular classroom. The following will elaborate on the reasons for its employability in my study. It is anticipated that mathematics teacher educators will appreciate the value of action research used in my study.

Recognised Research Methodology in Mathematics Teacher Education

Action research is recognised as one of the three methodologies noted in the literature in mathematics education research, the others being positivist research and interpretive research, though it is not always easy to typify the various research activities. Since both Ernest (1998, p. 72) and Wittmann (1998, p. 90) considered mathematics teacher education as one of the many foci of study for research in mathematics education, I can therefore establish action research as a valid methodology. This idea is further supported by M. Brown (1998), who judged the nature of a valid research by its wide acceptance in the research field (p. 264).

Intelligible and Workable Methodology for Improvement of Practices

As noted in Chapter One (page 14) and elsewhere in Chapter Two (page 27), the aim of my present study was to determine whether a constructivist approach could be used in a class of Chinese student mathematics teachers in HKIEd, and I needed a research methodology to accept or to reject such a teaching approach. As seen in a previous subsection of this chapter (pages 37-38), constructivism, as a theory of learning, has received a growing attention in mathematics teacher education in the west, but very few research findings have been reported in Hong Kong. Merely importing this idea into HKIEd, applying it without adaptation and without validating its effectiveness in a Chinese background was not my intention. As I am taking a (constructivist) research perspective to improve my teaching, naturally I would have preferred conducting an inquiry into its efficacy in a Chinese location, especially when the main method of teaching in higher education – the lecture method – seemed to be inadequate in altering student teachers' classroom performance, and where there is a paucity of research to inform practice.

A search of the literature on research methodologies reveals that action research is widely accepted for its potential power to change practice in one's workplace. Watt and Watt (1999) claimed that action research has a track record of successfully supporting change (p. 49). For instance, a recent successful example in changing the practices of a middle school mathematics teacher through an action research collaboration has been reported in Edwards and Hensien (1999). Also, both Cohen and Manion (1994, p. 186) and Webb (1996, p. 139) were impressed by the scope and influence of action research as a methodology. Both small-scale teacher interventions or large sophisticated organisational changes could be investigated by action research.

In reality, this reported potential power of action research to change lies in the emerging inconsistencies and contradictions encountered during the various stages of actions and self-reflections. Disconfirming evidence, in addition to that of a confirming nature, could provide the latent tendency to change (R. Winter, 1996, pp. 20-21) and hence the belief that improvement could be possible (Fullan, 1995, p. 258). This continual "reflective practice" (Elliott, 1991, p. 50) on disconfirming results, I believed, could thus empower me to identify and to improve my own practices (Hammersley, 1993, p. 214; Kemmis, 1993, p. 185).

Going through the literature search process, I found that action research is an intelligible, workable and easily accessed approach to self-initiated improvement of practices in any conveniently chosen class in my own workplace. A critical analysis of findings in the inquiry revealed that there are no restrictions on the use of data collection methods. I agreed with Cohen and Manion's (1994) claim that action research is particularly suitable for educational purposes with transformational intentions:

> Whatever the situation ... the method[ology] ... add[s] to the practitioner's functional knowledge of the phenomena she deals with. (p. 187)

Action research could address my own problems in practice, allow me to interpret my own understanding of the problems and suggest ways to enhance self-understanding and change for the better (Carr & Kemmis, 1986, pp. 129-130).

I also understood that in doing action research, I could inject an innovative or alternative approach to my teaching, and by developing self-confidence in the research field, I could become more likely to be ready to question and evaluate other research studies rather than to ignore them, or even worse, to accept them unquestioningly (Nickson, 1992, p. 108; see also Glanz, 1998, p. 21; Wiliam, 1998, p. 16).

In the light of its promising potential, action research was used in my study to inform and improve teaching practices in my workplace. Its success in effecting educational changes, as demonstrated by my study, hopefully adds to the literature on mathematics teacher education in a Chinese setting in Hong Kong.

Rigorous and Valid Form of Inquiry

M. Brown (1998) felt that action research can develop into valid and rigorous research if it is "well-theorized and systematically evaluated" (p. 265). The parallel criteria – criteria of credibility (validity), transferability (generalisability), dependability (reliability) and confirmability (objectivity) espoused by Guba and Lincoln (1989, pp. 236-243) could be a viable model. (A fuller account will be given in Chapter Three, pages 71-76.) Merriam (1998) echoed that by documenting action research, readers would have a full understanding of the educational process (p. 41), and a number of researchers (e.g., Hammersley, 1993, p. 217; Mason, 1998, pp. 360-362; McNiff et al., p. 107; Merriam, 1998, p. 32; R. Winter, 1996, p. 24) contended that a sensitive, tolerant and skilful author, who can present different participant perspectives on a complex local situation in a manner that is orderly, thorough, holistic, accurate and authentic, can actually help readers to replicate the research procedures, expand insights and meanings, and generalise their own interpretations to the wider population. In this respect, action research is a rigorous and valid methodology.

Thus, in my study, rather than ignoring the important criteria, for instance, validity, reliability and generalisability, in evaluating an inquiry (as suggested by Hanna, 1998, p. 402, and Mason, 1998, p. 360), I adopted the parallel criteria espoused by Guba and Lincoln (1989) in my study. (A fuller account will be given in Chapter Three, pages 71-76.) I endeavoured to:

- Provide as full a description of my site of investigation as possible (to meet the criterion of transferability);
- Record carefully and honestly my understanding and evidence of events that happened during my investigation (to meet the criterion of dependability and partially the criterion of credibility regarding disconfirming evidence);
- Store, as far as possible, raw data in computer files (to meet the criterion of confirmability but noting the ethical issues involved);
- Be an "insider researcher" (to meet the criterion of credibility in building trust and rapport and in facilitating immersing in the context's culture).

To further establish the criterion of credibility, I used the following techniques:

- Different kinds of data were collected from my students throughout the semester to match the different perspectives of learning and classroom environment – a kind of "member checking" (Guba & Lincoln, 1989, pp. 238-239);

- An extreme case sample (Patton, 1990, p. 170) to further inform confirming and disconfirming evidence and to overcome time and resources constraint (which could also be a kind of "member checking"); and
- A "disinterested peer" (Guba & Lincoln, 1989, p. 237) or a "critical friend" (Elliott, 1991, p. 80; McNiff et al., 1996, p. 85) to provide me with critical but supportive friendship.

In summary, besides being a recognised research methodology in mathematics teacher education as mentioned previously, the literature also reveals that action research could provide a rigorous and valid form of inquiry by exploring a single educational setting through different reflective phases, or reflective spirals. (In my case, two reflective phases were used; see Chapter Three, page 71, for detail.) On the basis of this finding, I had full confidence that proposed changes in my practices were well informed by action research.

The next subsection reviews action research as a powerful, vigorous and worthwhile form of professional activity which provides learning experiences for all participants involved (R. Winter, 1996, p. 25), and is another reason for its adoption in this study.

Professional Development

Although lecturers in higher education are required to conduct research as one of their university's missions (e.g., Gow, Kember, & McKay, 1996, p. 263; John, 1996, p. 121; Krantz, 1993, p. vii), there is a paucity of literature on educational leaders, higher education lecturers and teacher educators conducting action research to improve their own practice (e.g., Altrichter, 1997, p. 33; Cooke, 1998, p. 3; Diamond, 1991, p. 20; Glanz, 1998, pp. 4-5; John, 1996, p. 119; Kwo, 1998, p. 13; Tzur, 2001, p. 259). The poor response to an ERIC database search linking action research, teacher educators and mathematics in particular further supported this conclusion. However, researchers such as Glanz (1998, p. 20) and Rearick and Feldman (1999, p. 333) expected that more and more teacher educators would become lecturer researchers inquiring into their own practice as the value of the process became better known.

Though there are not many reports on action research in the local literature, Gow, Kember, and McKay (1996) claimed that "action research has [already] firmly established itself in Hong Kong as a mode of educational development" (p. 263) because of the substantial grant support for the inter-institutional "Action Learning Project" across the seven universities in Hong Kong (p. 263). Webb (1996) considered these projects in reality represented the majority of action research undertakings: efficiency and effectiveness associated with improvement (p. 151). However, Webb (1996) further commented that what was really beneficial was the cyclical lifelong learning process that effected changes in participants themselves, though not necessarily in the social context and organisation in which personal development took place (p. 152). This comment was indeed echoed by a number of researchers (e.g., Fullan & Hargreaves, 1992, p. 8; Marsh, 1997, p. 168; Melrose, 1996, p. 52; Zuber-Skerritt, 1996a, p. 95).

To me, action research, and in particular, the reflective spiral, offered an indispensable and powerful conceptual tool for understanding the teaching-learning processes and would bring about ongoing improvement in my practices within the current ever-changing conditions of my classroom and institution. Higher education teachers could become more professional, more interested in pedagogy and more motivated to integrate learning and research (Marsh, 1997, p. 169; Webb, 1996, p. 151; R. Winter, 1996, p. 25). This could further lead to greater job satisfaction, better quality programmes, improvement in student learning and educators' contribution to advancement of knowledge.

The literature also indicated that considerable demands would be made on me when conducting action research in teaching (Merriam, 1998, p. 24). As I had to work with students and colleagues, and other people connected with the research, I had to be acceptable to all parties (Ball, 1993, p. 42). I was to be a proactive learner, knowledgeable, systematic (McNiff et al., 1996, pp. 32-33), skilful in communication (Marsh, 1997, p. 169; McNiff et al., 1996, pp. 32-33; Merriam, 1998, pp. 23-24), open to ways of thinking (Elliott, 1991, p. 49), patient (Merriam, 1998, pp. 20-21), sensitive to students' responses (Merriam, 1998, p. 21) and capable of selecting and organising theories, concepts and ideas in response to students' search for personal meanings (Elliott, 1991, p. 52; Marsh, 1997, pp. 168-169).

The implicit underpinning of action research, to me, seemed to be the theory of constructivism. The implication is that as a teacher educator, I must be a proactive constructivist possessing educational ideals, believing in the possibility of change, and actively assisting my student teachers and myself in constructing understandings of curriculum and pedagogy in the local situation. I should be a role model to exemplify the essential concepts in teaching – teachers as researchers and teachers as lifelong learners. In so doing, I would anticipate that my student teachers and others could agree with me that

> Action researchers tend to be working intentionally towards the implementation of ideas that come from deep-seated values that motivate them to intervene. (McNiff et al., 1996, pp. 9-10)

and hence develop ourselves professionally. Professional development by way of action research is thus part of my contribution to the body of literature in this respect.

SUMMARY

As reported in Chapter One (e.g., page 6), Hong Kong has been influenced by western philosophy and culture, and traditional Chinese values have been diminished. Hong Kong has also seen the intensification of curriculum reform during the last 25 years. At the time of writing this report, the Education Commission (2000) was engaged in a major and ongoing comprehensive review of the overall education system in Hong Kong. (The Education Commission is an advisory body appointed by the government to give advice on the development of the Hong Kong education system.) According to Morris, Lo and Adamson (2000),

> At this juncture of Hong Kong's history, educational reform generally and curriculum reform specifically have been placed at the forefront of the policy agenda as the government strives to improve the quality of schooling and re-create Hong Kong as both a part of China and a part of the global economy. (p. 245)

As seen in Chapter One (e.g., page 14), reform initiatives employed the principle of social constructivism as a framework. For example, in the Target-Oriented Curriculum renewal in Hong Kong, teaching employed

> A more active and purposeful construction and use of knowledge through engaging students in relevant, contextualised learning tasks .... Highlighting the interdependence between language and learning, and between knowledge and ways of representing and communicating it in speech and writing. (Clark, Scarino, & Brownell, 1994, p. 10)

In the recent reform, transmission of knowledge was shifted to the encouragement of pupil thinking, communicating and co-operating (Education Commission, 2000, pp. 29-30).

If improving teacher capability was at the heart of curriculum renewal, then as a teacher educator, I had the responsibility to educate my student teachers in adopting and employing the constructivist pedagogy in teaching (among other models of good practice). Since my experience in educating student teachers in Hong Kong informed that my students possessed traditional approaches to teaching mathematics, I was in need of a learning theory to change my student practice.

I learnt the theory of constructivism while I was studying at Curtin University, and a review of literature (in Chapter Two, pages 34-40) informed that constructivism, widely researched in western countries, could be a means to change my students' teaching beliefs. Since there was as yet no exemplary model in educating teachers in Hong Kong, and teacher training in Hong Kong seemed unsuccessful in innovating teachers for change (see Chapter One, pages 8-12), I decided to trial the constructivist theory. According to Clark, Scarino, and Brownell (1994), one of the common patterns in educational reform around the world was "a move towards more learner-centred education .... Education should lead to better and more independent thinking and creativity, rather than focusing on recall" (p. 11), I believed that employing a constructivist theory could serve such a purpose. Furthermore, what was needed in Hong Kong were original studies, such as my study – an aspect of my research I considered to be perhaps its most significant contribution to the literature.

In order to investigate the efficacy of social constructivism as a theory in educating my students, I employed a two-phase action research. Besides aiming to develop my students' awareness of the use of the more learner-focused teaching approaches by way of self-articulation, reflection, and discussion, I sought also to develop my own theories of learning, research knowledge and social skills.

Chinese student mathematics teachers may find difficulties in their learning in a classroom where constructivist approaches were being used. The concept of adequacy or viability espoused by social constructivists contradicts Chinese students' entrenched understanding of the nature of knowledge developed during their schooling. Chinese are used to lectures. They regard their teachers' words as truth, and the product of learning is the reproduction of knowledge passed to them from their teachers. Anything other than that is considered wrong. If they are told that there is no right or wrong answers with learning theories, and that learning theories can be either sufficient or inadequate when being used to gain understanding of a particular situation in a particular context, they may refuse to accept it. Students may feel rather uncomfortable in class. Time and other viable methods may be required to change this belief.

The familiar transmission classroom may prove difficult to change to a constructivist one in Hong Kong. A social constructivist approach demands discourse. The habit of keeping silent and of simply listening without talking or without engaging in communication is so common in student teachers that they may not be willing to switch to the social interactive mode of learning in class. Student teachers expect to be told, but in a constructivist learning environment, active participation for everyone is required instead. Some student teachers may find difficulties in articulating ideas of teaching, which is demanded in a constructivist approach. Others may lack the relevant social and interpersonal skills in discussion, in sharing, in launching and accepting challenges, in negotiating and in drawing a joint conclusion. Furthermore, presenting oneself in class for judgement could mean a loss of face, and contradicting others would mean disruption of harmony. Thus, avoiding losing face and upsetting peace or unity can prevent students from participation in class. Moreover, articulation of teaching ideas and knowledge construction may all take time. The time constraint in the school setting also renders the implementation of a constructivist approach in a Chinese setting problematic.

These were the problems facing me as I commenced this research study. It was obvious that Chinese student teachers would need more than simply content knowledge and knowledge about teaching in a constructivist-style classroom. Learning the skills of working together, in addition to the acquisition of pedagogical content knowledge, should also be planned. Similarly, I would need to possess good social and interpersonal skills as well as relevant knowledge about mathematics teaching and research.

Though there may be cases in which the social constructivist approach succeeds in facilitating learning in a Chinese setting, the paucity of research findings to inform the kind of framework built on social constructivism warrants further research. The next chapter reports how such an inquiry was conducted.

CHAPTER THREE

METHODOLOGY

INTRODUCTION

The purpose of this chapter is to report on the practical aspect of the methodology employed to examine the efficacy of a constructivist approach in the training of preservice Chinese mathematics teachers. The literature review in Chapter Two indicated that action research could be used as a rigorous and valid method of inquiry in mathematics teacher education when attention has been paid to the characteristics of the learners in a Chinese community (pages 53, 59-69). The principles of action research were easy to understand, and data collection could be carried out in my workplace – a task that I could manage. In interpreting the findings in my own institution, I could learn from my own teaching and hence effect changes in student teachers' learning. Over time, I could gain confidence in my teaching, develop myself professionally, and contribute to the development of better quality programmes in HKIEd. After first outlining the research design (including ways to maximise rigour), this chapter describes the implementation of the present research work, including the details of teaching Chinese learners in HKIEd and the instrumentation employed. Precautions taken relating to ethical considerations are then reported.

RESEARCH DESIGN

Action research was used to answer the research questions stated in Chapter One (page 17). It informed me of (1) my student teachers' prior knowledge about teaching, (2) the engagement of my student teachers in activities which involved elements of self-articulation, self-reflection and discourse, and (3) the impact of such a learning environment on student teachers' beliefs about teaching.

The commonly accepted reflective spiral in action research (reviewed in Chapter Two, page 57) facilitated my actions for improvement and prompted two phases of implementation. The first phase investigated the deficiencies in both my teaching and research methods, and allowed me to make plans for the second phase actions. The second phase saw the retrial of my teaching and the evaluation of the improved teaching approach. They are now described in more detail.

The Two Phases of Action Research

The common notion of the action research spiral suggested a minimum of two phases of inquiry, with the second one modified in the light of what was learned from the first. In my study, I designed two implementation phases, with a different class of first-year Chinese mathematics students in each phase. Data was collected in each case, with the aim of providing the clearest possible description of events happening in my tutorial room. Interpretation of data then led to a tentative explanation of what happened – it helped me to monitor the learning tasks designed for my students and provided feedback to me for further planning and replanning of subsequent actions. The findings of the first phase were used to guide and to improve my teaching in the second phase, at the end of which an overall evaluation of the study was carried out. The two phases together formed an action research spiral that was comparable to the processes stipulated in Elliott's principles of action research (1997, reviewed in Chapter Two, pages 58-59) and which focused my data collection and interpretation processes. Furthermore, different ways to maximise research rigour were employed.

Maximising Rigour in the Study

As mentioned in Chapter Two (page 62), I employed Guba and Lincoln's (1989) parallel criteria for maximising rigour in my research design. The following shows how the quality criteria: credibility (validity), transferability (generalisability), dependability (reliability) and confirmability (objectivity) are addressed in my study.

Credibility

Prolonged Engagement and Observation

To increase the credibility of the study, Guba and Lincoln (1989, p. 237) suggested a prolonged observation on my part of both my students' learning and the constructivist learning environment I created. As a teacher of the methods class (and an "insider researcher") throughout a semester, I actively immersed myself in the classroom, built rapport and trust from my students and interacted sufficiently with them to uncover my students' teaching beliefs and the impact of the learning environment on their learning.

Multiple Data Collection Methodologies

To perform "member checking" – testing hypotheses, data and interpretations (Guba & Lincoln, 1989, pp. 238-239), I used different data collection methods during the class meetings, because action research supports the use of a wide variety of research methods in any single site investigation. However, statistical methods alone were insufficient for my research purpose. Statistical averages can of course give an overall profile of my teaching, but these quantitative measures – claimed to be designed to predict learning outcomes – are inadequate in describing or measuring the complex individualised learning experiences taking place in the classroom. I could not predict the outcomes of my teaching – they depended on how my students approached the learning experience, what their needs were, and which part of the activity they found most interesting and stimulating. I could only focus on "matches" (Guba & Lincoln, 1989, pp. 236-237) among emergent events which prompted any changes for the better. Thus, I needed methods involving observations, interviews and descriptions of activities in order to have a better understanding of my students' behaviour (Patton, 1990, p. 169). It followed that multiple methodologies – a wide selection of data collection methods contributing to as detailed a data base as possible – would be advisable in studying classroom interactions.

Extreme Case Sampling

During the process of learning, all student teachers in my class were required to write journals and to complete questionnaires. To verify the results obtained from them, Guba and Lincoln (1989) supported the use of interviews with individuals or groups in order to maximise credibility (p. 239). Similarly, Merriam (1988, p. 48) and Patton (1990, p. 169) maintained that if one wishes to improve the effectiveness of a programme in a class of pupils, one may learn a great deal more by focusing in depth on understanding the needs, interests and incentives of a small number of carefully selected pupils. The focus is on relatively small samples, even single cases, selected purposely with a view to establish generalisation about the class of pupils to which the sample belongs (Cohen & Manion, 1994, pp. 106-107). Patton (1990) purported that standardised statistical methods involving large samples selected randomly are less appropriate in studying complex educational situations, as in my study, especially when limited time and other constraints render interviewing everyone and observing everything in class impossible (p. 169).

Patton (1990) further argued and suggested that extreme or deviant case sampling could provide information-rich cases to illuminate my question under study. By intensively studying unusual or special cases, for instance, outstanding successes (or notable failures), lessons may be learnt about usual conditions or extreme outcomes that are relevant to improving some typical programmes (p. 170). Patton (1990, p. 170) and Merriam (1988, p. 50) also believed that detailed information about special cases may even supplement statistical norms. It was the latter suggestion that partially supported my plan to observe and interview a case of three outstanding student teachers in addition to the quantitative (and qualitative) data collected from the whole class.

There were other considerations. Since the focus of my inquiry was on student teachers' learning and their perception of the learning environment, Maykut and Morehouse (1994) contended that the choice of the students in my case depended very much on my students' ability to connect new information with prior knowledge (p. 59). In other words, when compared with their peers of the same class, academically outstanding students were more capable of connecting new information with their prior knowledge (see also Nisbet & Putt, 2000, p. 101). Furthermore, because the student teachers were chosen on the basis of their achieving high grades in semester one in HKIEd, they should possess the relevant prior knowledge in teaching and learning. Thus, they should be more able to reflect on their learning in their journals, teaching and interviews, and have a better understanding of the learning situation I created in the study. Besides, as seen earlier, Chinese learners are generally active learners with a high achievement motivation. These chosen ones would be highly motivated and willing to participate actively in class – a prerequisite to constructivist learning.

Maykut and Morehouse (1994) also posited that there are gender differences in how knowledge is received, understood and integrated, and to fully understand the phenomenon of learning (from a constructivist classroom), I would probably want to involve both women and men in my study (pp. 59-60). Thus, the case I was using consisted of both men and women student teachers. From my experience in teaching the methodology module, and to balance with the limitations of time and resources (Maykut & Morehouse, 1994, p. 63), the manageable size of my case study group was restricted to three.

Disinterested Peer/Cooperating Colleague/Critical Friend

In addition to obtaining perspectives of my teaching performance from my students, I also strove to elicit the understanding of the evidence inherent in the data from one of my colleagues, a "disinterested peer" (Guba & Lincoln, 1989, p. 237) or the "critical friend" (Elliott, 1991, p. 80; McNiff et al., 1996, p. 85), in the Department of Mathematics. I was in the best position to explain my pedagogical aims, my students delineated the influence of my actions, and my colleague observed and provided feedback on the interactions among student teachers and me (McKernan, 1996, p. 185). This colleague of mine knew my students and is knowledgeable in teaching and teacher training. Despite her heavy commitment to teaching, supervision and administrative work, she was willing to provide critical but supportive friendship, to engage in conversation, to share progress and information, to offer feedback, and to provide support and challenge so that I could probe more deeply and critically into classroom actions (Guba & Lincoln, 1989, p. 237; Hargreaves, 1995, p. 16; McNiff et al., 1996, pp. 30-31, 85). The critical friend's easy accessibility and her familiarity with the system in the workplace were crucial to my research study.

Transferability, Dependability and Confirmability

Guba and Lincoln (1989) cautioned that in the process of "member checking", it was the meaning and understanding, but not the specific data of a factual nature, that should be checked (p. 241). Since data analysis in action research is an ongoing activity that seeks to understand what is happening from the point of view of the participants involved, data were actually analysed continuously throughout all the stages of the study (e.g., Guba & Lincoln, 1989, p. 239). This satisfied the criterion of credibility. After each lesson, I immediately wrote my record of lessons and reflections and stored them in computer files. I endeavoured to recall the events in my constructivist classroom as accurately as possible, identify learning patterns, collect confirming and disconfirming evidence. Data obtained were analysed honestly and recorded carefully, and, as far as possible, saved in my computer in order to establish the criterion of confirmability (see also research ethics at the end of this chapter, pages 111-112). On a weekly basis, I fine-tuned my research questions, reflected on my understanding of the evidence recorded, planned my lessons and ways to interact with my students in order to collect further confirming and disconfirming evidence. At the end of Phase I of my study, I reflected on the entire body of data and analyses that had been conducted, combined different interpretations, evaluated the results and reformulated my plans for Phase II implementation. The same process of describing in detail events and formulating meaning and understanding of data collected – at the end of each lesson, on a weekly basis, and at the end of a phase of investigation – was repeated in Phase II. At the conclusion of my study, I wrote up the thesis in great detail, provided a full description of my methodology (to meet the requirement of transferability) and presented my results and arguments honestly (to meet the requirement of dependability).

THE COURSE AND MODULE

Phase I of this study extended from February 1998 to the end of June 1998 (semester two, 1997-98), and Phase II from January 1999 to the end of June 1999 (semester two, 1998-99). In both phases, I was assigned to teach first-year student teachers a compulsory methodology module in semester two of each academic year. My teaching duties enabled me to conveniently conduct this inquiry, and I considered this to be an important opportunity to develop my own teaching methods. This section gives an overview of the course in which my student teachers were enrolled, followed by an outline of the specific module involved in this study.

The Course

Student teachers involved in this study were first-year Chinese student mathematics teachers of the Certificate in Secondary Education (Chinese) Course (Two-year Full-time) (2SC). This course is a preservice course to prepare teachers to teach two subjects at junior secondary levels (for pupils aged 12 to 15) in secondary schools using Chinese as the medium of instruction. The main medium of instruction in the lectures is also expected to be in Chinese; nevertheless, reference materials could be in English due to the paucity of Chinese references.

Student teachers, all being Chinese, are expected to have little problems in using the Chinese language, both orally and in writing, but they might have difficulties in understanding materials prepared in English. The 2SC students enrolled in mathematics as an elective subject should have at least passed Advanced Level Mathematics out of the two Advanced Level passes required – which is an entry requirement to the course (see Chapter One, page 13). Consequently, these student mathematics teachers are considered competent in junior secondary mathematics subject knowledge.

The 2SC students have to take a total of 60 credit points (equivalent to 900 contact and directed studies hours, excluding field experience) full time for the whole course, which extends over four semesters or two years. An academic year in HKIEd begins in September and ends in June the following year, and consists of two semesters – the first between September and December and the second from January to June. Each semester consists of 14 weeks, with the last being a non-teaching week allowing student teachers to complete and submit their assignments. The summer break then begins in early July.

The Module

There are altogether nine mathematics modules, each of two credit points, and only two modules (all compulsory) are about teaching methodology. Student mathematics teachers are required to attend and pass the first methodology module: Teaching Mathematics in Junior Secondary School (I). It is offered to all first-year student teachers majoring in mathematics in semester two every year, and it was in this methodology classroom that the present study was conducted. The methodology module is worth two credits and consists of a total of 30 contact and directed studies hours. It aims at providing student teachers with knowledge of the teaching of specific topics in junior secondary mathematics in Hong Kong. (The outline of this module can be found in Appendix 3A, page 318.)

The methodology class, with an anticipated number of 30 students, meets for two hours every week; but because the semester generally comprises only 13 weeks (as pointed out in the previous subsection), there are a total of 26 face-to-face teaching hours. As teaching practice falls within the second semester, after the first few meetings the class will break off for the April-May teaching practice in secondary schools, but formal classes resume when all student teachers return from their field experience.

There are then normally five weeks left or five more meetings to complete the module before the summer break, and student teachers of this class will be fully occupied with their module assessment – presentation of individual planned teaching approaches (and after which a report has to be submitted by individuals as formal assessment). Student teachers will be asked to evaluate the module in the final meeting.

Having set the scene for the methodology module, I will next report my teaching in Phase I. Though most of the data collection activities were completed during the class meetings, I find it more appropriate to delineate the data collection process and the types of data separately afterwards.

PHASE I: MY TEACHING

Phase I of the study commenced in February 1998 and ended in June 1998. The sample consisted of 23 first-year student teachers (2SC-97 Class or Class-97) whose demographic details will be given later in this chapter ("Phase I: Sample Details", pages 86-88). Table 3.1 depicts the teaching schedule of the first phase, showing the exact dates of the meeting. During this phase, the move of HKIEd into its new campus in October 1997 delayed the start of the academic year by a month – from September to October, and as a result, the second semester began in February 1998 instead of in January. The summer break was scheduled as usual for July, thus the second semester had been shortened to only 12 weeks, the last being the non-teaching week.

Table 3.1
The Schedule for Class Meeting in the Academic Year 1997-98 (Phase I Implementation)

Date (Monday)	Class meeting	Activities for class[a]
16 Feb 1998	1	Briefing: Class meetings, assessment
23 Feb 1998	2	Teaching of concepts
2 Mar 1998	3	Teaching of concepts
9 Mar 1998	4	Teaching of concepts
16 Mar 1998	5	Teaching of skills
23 Mar 1998	(School visit before field experience)	
30 Mar 1998	6	Briefing for teaching practice Teaching of principles
20 April 1998 - 22 May 1998	(Field experience)	
25 May 1998	7	Assessment: Individual presentation (5 student teachers)
1 Jun 1998	8	Assessment: Individual presentation (6 student teachers)
8 Jun 1998	9	Assessment: Individual presentation (6 student teachers)
15 Jun 1998	10	Assessment: Individual presentation (6 student teachers)
22 Jun 1998	11	Debriefing Module evaluation
29 Jun 1998	12 (Non-teaching week)	Submission of individuals' assessment reports
July 1998	(Summer Break)	

Note. [a]Most data collection activities have been included in the class activities.

Overall, based on the nature of classroom learning activities, the 11 weeks were organised into four blocks: (1) the first meeting, (2) before student teachers' class assessment, (3) class meetings with assessment, and (4) the last meeting.

First Meeting

At the beginning of the first meeting (Monday, 16 February 1998), student teachers were briefed on the general conduct of the module, the arrangements of the class meetings and the assessment details. Assessment of student teachers in this module takes the form of a planned individual class teaching session on a selected topic in junior secondary school mathematics, followed by the submission of a report on the presentations in the non-teaching week.

The topics in the assessment task were provided by me, and allocation of topics to individual students was by lot. After the introduction and the lot drawing, the remaining time of less than an hour was used first by me, to explain to students my research study, and then by student teachers to complete the relevant questionnaires (see subsection "Phase I: Implementation Timeline" later in this chapter, pages 98-100).

The sample of student teachers involved in this study had to know at the very outset that an alternative approach to learning would be used in the methods class. They had to be prepared psychologically for the fact that the usual familiar secondary school classroom situation in which direct teaching and pupil listening had been the norm, and from which they had just graduated, would no longer be used. They were told about the characteristic features of the lessons and the respective role to be played by each of them and me. I made it clear to them that each of us had to contribute to the lessons, that they were expected to participate actively in group and class discussion, and that this would mean that they would have more autonomy.

The Period Before Class Assessment

Before student teachers' field experience in April and May, members of the Class-97 met every Monday afternoon for two hours. These lessons aimed at developing student teachers' ability to teach various topics in junior secondary mathematics. It was in this block that the social constructivist teaching model – problem posing, self-articulation, constructing and reconstructing ideas, and self-reflection – discussed in Chapter Two (pages 40-47) was implemented. Student teachers' journal writing as one of the data collection methods had also been incorporated into the learning activities.

The timing for the various activities for each of the two-hour sessions is shown in Table 3.2 – of course the time allocation was adjusted whenever necessary.

Roughly ten minutes were used for each step of the constructivist approach – namely, self-articulation, group discussion and self-reflection. Since I considered a group size of four to be appropriate for discussion, the 2SC-97 students were divided into five discussion groups. Student teachers were allowed to form their own groups, but they were restricted to include no more than five people in one group. As a result, I had to assign some students to groups which they were unwilling to join, meanwhile promising these student teachers that there would be a change in the membership after one or two meetings. Each group was given a different topic for discussion, and 15 minutes were allocated for each group to present to the Class-97 their discussion results for comments. Appendix 3B (page 319) was a typical worksheet designed with the foregoing ideas in mind and will be explained later.

Table 3.2
Time Allocation for the Different Activities in a Typical Social Constructivist Classroom Session, Phase I, 1997-98

Activity	Time allowed (min)
Self-articulation	10
Group discussion	10
Class discussion	75[a]
Self-reflection	10
Total	105

Note. [a]15 minutes were required for one topic, and there were altogether five topics.

A group leader was then elected in each group to lead discussion, to consolidate the different ideas from members of the group and to present the results of the discussion to the Class-97. Student teachers were again promised that they would take turns to lead discussions. Indeed, in every later meeting, discussion groups admitted new members from other groups, and different student teachers voluntarily chaired and presented group results; thus many student teachers had a chance to experience the role of a discussion leader.

After the formation of groups and selection of group leaders, each student teacher was given a discussion worksheet – similar to Appendix 3B mentioned previously – on which various activities were stated. As noted in Appendix 3B, these activities involved self-articulation, group discussion and presentation, discussion of different topics and the self-reflective process, including comments on the classroom learning environment. As mentioned already, each group was assigned a different discussion topic, and the maximum amount of time for group discussion was about 10 minutes. However, before the group discussion, individual student teachers were asked first to spend a similar length of time in articulating their own teaching ideas on paper, and they were told that the self-articulation would have to be submitted at the end of the meeting. During self-articulation and group discussions, I encouraged individuals to express and to defend their own teaching points, and to query others' assertions. I also answered student teachers' queries and participated and assisted in group discussions. Thus, student teachers not only had a deeper understanding of their own viewpoints, but they were led to examine others' ideas as well. This activity perturbed existing teaching ideas and facilitated a change and adoption of more viable teaching methods.

Each group then presented their discussion results to the Class-97 via an overhead projector for whole-class discussion (each presentation and discussion took about 15 minutes) during which I acted as the chair, a time controller and a mediator of different ideas and questions raised. If necessary, I reminded my students that we were focusing on issues about teaching and not on attacking individuals. The reminder encouraged my students to discuss openly without worrying about losing face. Afterwards, student teachers were asked to reflect on what had been debated and to write down their "conclusions" on the same worksheet (about 10 minutes were allowed), which I would collect before student teachers left the room. During each of these meetings, student teachers retraced the same constructivist learning sequence, but of course the contents and details of the worksheets were designed differently for different meetings.

In this block of teaching when the constructivist approach was implemented, attention was paid to the several points raised by the literature review on Chinese thinking and behaviour.

While providing beginning student teachers with the proper orientation to the new approach, I was concerned to ensure that the requirement for student teachers to change from a passive learner to an active one should not be too drastic. Particularly in the first couple of lessons, I provided them with more guidance and now and then included some form of direct teaching. The importance of this was to allow the student teachers to experience greater security, as they would still feel the existence of the systematic guidance and direct instruction which they were accustomed to. Worksheets which guide self-articulation and group and class discussion were prepared – this, supported by my timely and appropriate input, could possibly facilitate knowledge construction.

Chinese learners are nurtured to respect the hierarchical relationship between teacher and students. Rather than accepting this as a barrier to the implementation of my constructivist approach, I made use of it positively in my role as a mediator and facilitator. In the tutorial room, student teachers were frequently and necessarily reminded that we were all equal, but they could consider me the "expert" to turn to. Thus, because of my seemingly superior position, I exercised this privilege to encourage the student teachers to express their own opinions or to solve a problem by themselves, and I directed stimulating questions to them whenever I perceived the need. I further assured student teachers that because they are all equal, all their opinions are to be respected, and any critique should be considered to be pinpointing the issue itself, not any individual. If there was any disagreement among student teachers, I served as a middle man. However, I strove to be fair, but not too close, to all groups. I balanced praise and criticism, with the latter conveyed sensitively. Overall, I let student teachers perceive the constructivist classroom as a safe place to disclose themselves, to accept compliments and to admit failures.

Student teachers obviously expected that I, the lecturer, being knowledgeable in my field of study, should guide and teach them. Thus, my duty was first and foremost to prepare each lesson well. I tried to provide unambiguous instructions during the lessons. This not only helped student teachers in their knowledge construction, but also avoided situations in which student teachers were forced to question me for further details about the instructions – an act which seemingly disrespected the authority in the tutorial room and which students might hesitate to do. Clear instructions could also develop student teachers' confidence in what and how they should perform, and reduce their worry about acting inappropriately and hence embarrassing themselves. The support and care I provided may perhaps be perceived as "too much" in a western setting, but to meet the cultural needs of my students, they were important in reducing any fear of risk taking and encouraging participation in a new learning mode.

My input seemed paramount. In addition to assisting in constructing knowledge about teaching, the degree, extent and promptness of my comments would affect student teachers' perception on my effectiveness in teaching. Chinese student teachers would feel that ineffective teaching is taking place if they are continually asked in the tutorial room to express their opinions and discuss among themselves, without the lecturer's direct involvement. They may even consider the "lecture" ill-prepared. Consequently, I strived to select carefully what should be provided to students through more direct teaching and when that should take place – in other words, when and how I should exercise my "authority" in order that the learning environment was received by student teachers and yet met the criteria of a constructivist classroom.

If possible, more time was allowed for student teachers to think about the topics being discussed. Since student teachers tend to teach in the way they were taught, providing them with sufficient time to think over and evaluate their original belief is particularly important. Furthermore, as student teachers are not used to the new learning style, they needed more time to organise their ideas and then present them orally, and to consolidate intuitive ideas in writing. In particular, with a high disposition to learning and to doing well, student teachers undoubtedly would need more time to frame their presentation in order to avoid what they may perceive as "mistakes". This meant that there was to be some "silent period" in a lesson and that I should not consider silence in the tutorial room to be a sign of students refusing to participate.

Class Meetings With Assessment

After the teaching practice, module assessment was arranged. Student teachers were required to present to the Class-97 their own teaching plans within 20 minutes (including class discussion) on the particular topic assigned (by drawing lots) in the first meeting. After the class discussion, student teachers' self-reflection was to be completed at home, and the result of the self-reflection in the form of a report had to be submitted in the non-teaching week.

A particular student teacher was also chosen to chair one student teacher's presentation and to lead discussion (also decided by lot in the first meeting). This was similar to the group discussion leader's role in class meetings in the second block before the teaching practice. Taking up the role of chair of class discussion was an opportunity to develop confidence in speaking out in class – a preparation for future teaching. Articulating one's own viewpoints about teaching allows a more in-depth understanding of teaching and learning as well as a critical analysis of others' ideas.

My role in these presentation sessions became that of a class member, having the opportunity to participate equally as my student teachers, but I also acted as an assessor of the presenters' ideas about mathematics teaching. Nevertheless, the time allowed for individual presentations had to be strictly monitored, otherwise, not everyone in the Class-97 could be assessed.

The Last Meeting

The final meeting (Monday, 22 June 1998) served two purposes. The first was for me to debrief my student teachers; the second was for student teachers to complete a module evaluation form issued by HKIEd officially. The latter also provided feedback to me regarding teaching and learning of the methodology module. (In addition, student teachers were asked to complete other questionnaires for the study – see subsection "Phase I: Implementation Timeline" later in this chapter, pages 98-100.) In case student teachers absented themselves from being assessed in previous class meetings, they were asked to present their teaching plans in this final session as a "make-up" for the presentation part of the assessment.

PHASE I: SAMPLE DETAILS

As mentioned earlier in this chapter (pages 76-78), the sample consisted of a class of first-year Chinese student mathematics teachers enrolled in the Certificate in Secondary Education (Chinese) Course (Two-year Full-time) in the academic year 1997-98. These 2SC-97 students assisted me in the present study by their attendance and active participation in class, and by providing information concerning their beliefs about mathematics teaching and about the learning environment created in the classroom. During the class meetings, they were required to complete different questionnaires, to express their ideas of teaching and comments in journals and to participate in discussions and presentations.

In the first phase implementation, there were 23 student teachers in my methodology class. Table 3.3 shows their demographic details. As already mentioned in this chapter (pages 76-78), these student teachers all enrolled in the two-year full-time preservice course which prepared them to teach junior secondary levels in Hong Kong Chinese-medium secondary schools. They were all young Chinese – 6 female and 17 male – who passed the Advanced Level Mathematics as one of the entry requirements to the course. Moreover, this sample of students possessed no previous teaching experience.

I also invited three outstanding student teachers (denoted by S1, S2 and S3) from the same class to form a case study group (Case-97). (The rationale for employing outstanding students was given in the "Research Design" section at the beginning of this chapter, pages 73-74.) To further investigate student teachers' learning about mathematics teaching, it was pertinent to observe in more detail the group members' beliefs about teaching, and the application of their knowledge to teaching in the actual classrooms. However, it was impossible either to interview all the 23 student teachers after the class meetings or to supervise all of them in their teaching practice in secondary schools between April and May. We were all too busily engaged in a variety of other commitments. Student teachers were heavily involved in their own learning and in various activities on- and off-campus; I myself had been assigned supervisory, teaching and administrative duties, particularly as there had been a considerable amount of programme upgrading and validating processes going on in HKIEd. Thus, a profound study of the three students' learning was more suitable to the limitation of time and resources.

Table 3.3
Demographic Details of Student Teachers Participating in Phase I Study, 1997-98 (N = 23)

Characteristics	n
Course	
Certificate in Secondary Education (Chinese) Course (Two-year Full-time)	23
Gender	
Female	6
Male	17
Age	
19 - 22 years	23
Ethnicity	
Chinese	23
Qualifications	
Pass in Advanced Level Mathematics	23
Teaching Experience	
Nil	23

Similar to other student teachers, these three case study trainees attended and participated in class and in assessment activities; they also wrote journals and completed questionnaires. In addition, the case students agreed to be observed once in their teaching practice in a secondary school during April and May, 1998; they also consented to be interviewed immediately after their lessons and to the audio taping of the post-lesson dialogue. During the non-teaching week, the three student teachers, though busily preparing for their assessments, agreed to be interviewed again on their beliefs about teaching and other matters related to my conduct of the methodology module.

Table 3.4 shows the particulars of the three student teachers of the Case-97, their gender and the types of schools in which they carried out their teaching practice.

Table 3.4
Particulars of the Three Outstanding Student Teachers in Phase I Study, 1997-98

	Three outstanding student teachers		
Characteristics	S1	S2	S3
Gender	Female	Male	Male
Academic result in mathematics, semester one, 1997-98	Top	Top	Top
School for teaching practice[a]	Band-five	Band-two	Band-five

Note. [a]Hong Kong secondary schools are divided into five bands: from "band-one, band-two" to "band-five". Primary year six pupils are ranked from top to bottom according to their overall academic results in primary year six. The top 20% of pupils in this ranked list are admitted into "band-one" schools for secondary education, and so on; the bottom 20% in this list are allocated to "band-five" schools.

S1 (female), S2 and S3 are all outstanding – amongst the top in the class of 2SC-97 students in their academic results in mathematics in the first semester, 1997-98. They were placed in secondary schools in April for their teaching practice. S1 and S3 were placed in "band-five" schools for field experience, whereas S2 was teaching a "band-four" school. (To pursue secondary education in Hong Kong, all primary year six pupils are firstly ranked from top to bottom according to standard scores – which are converted from their overall academic scores in their own primary school. The ranked list of pupils was then divided equally into five equal parts. The top 20% of pupils in the list will be admitted into "band-one" school for secondary education, the next 20% in the list into "band-two" schools, and so on; the bottom 20% of pupils in the list will be allocated to "band-five" schools.)

In the next section, I will describe the instrumentation and the data collection methods.

PHASE I: INSTRUMENTATION

As mentioned previously in this chapter (see the "Research Design" section at the beginning of this chapter, pages 71-76), for triangulation purposes, different kinds of data were collected from all the 2SC-97 students. However, to have a deeper understanding of student teachers' beliefs and to allow for time and other resource constraints, three outstanding students were interviewed and their classroom teaching observed (see the subsection "Extreme Case Sampling" at the beginning of the chapter, pages 73-74). The critical friend supported me in my interpretation of the results obtained (see the subsections "Disinterested Peer/Cooperating Colleague/Critical Friend" and "Transferability, Dependability and Confirmability" at the beginning of this chapter, pages 74-76).

The inquiry investigated broadly two issues: (1) student teachers' beliefs about teaching and (2) the classroom learning environment. The instruments were selected, adapted and designed with these two aims in mind. Table 3.5 shows the various data collection methods and the corresponding data sources.

Data collected was divided into two types: that from structured questionnaires and free responses from semi-structured interviews and journals. Fixed responses to items on a Likert scale included questionnaires on beliefs about teaching mathematics (BTM) and constructivist learning environments (CLE). Open-ended questions or semi-structured questionnaires included the general teaching sequence (GTS) questionnaire, the interview schedule (beliefs about teaching mathematics) (INT) and the journal writing (JWW) worksheets.

The instruments, the time of implementation, and data collection and analysis will now be described in terms of the two broad purposes of the study just described – first my students' beliefs about teaching and then the social constructivist learning environment.

Table 3.5
Data Type and Corresponding Data Source in Phase I Study, 1997-98

Data Collection Method			
(1) Student teachers' beliefs about teaching		(2) Social constructivist learning environment	
Name	Data type	Name	Data type
Student teachers – All			
Beliefs About Teaching Mathematics (BTM) questionnaire	Likert scale (1 to 5)	Constructivist Learning Environment (CLE) questionnaire	Likert scale (1 to 5)
General teaching sequence (GTS) questionnaire	Open response	--	--
Journal writing (JWW) before class assessment	Open response	Journal writing (JWW) before class assessment	Open response
Three selected student teachers (S1, S2, S3)			
Interview (INT)	Open response	Interview	Open response
Teaching practice observation and post-lesson interview	Open response		

Collecting Data on Student Teachers' Beliefs About Mathematics Teaching

This section introduces the different data collection methods that I used to study student teachers' beliefs about mathematics teaching, namely, teaching orientation, general teaching sequence and specific teaching methods; and also the interview schedule and teaching practice observation.

The Beliefs About Teaching Mathematics (BTM) Survey

To provide a wider perspective on my students' beliefs about teaching mathematics, I tried to search for a quantitative instrument (in addition to the qualitative ones) for the present study. According to Malone and Ireland (1996, p. 124; see also Edwards & Hensien, 1999, p. 188), a considerable amount of research had been reported world-wide on changing teaching beliefs. However, nothing was detected in Hong Kong. A present International ERIC search indicated that there was a paucity of literature specifically on beliefs about teaching mathematics. Out of the few, I could find the journal article by Van Zoest et al. (1994).

I was introduced to Van Zoest's Beliefs About Teaching Mathematics Survey when attending a tutorial conducted by my supervisor in Curtin University of Technology. Van Zoest et al. (1994, p. 41) reported that the belief items in the survey encompassed three components of the teacher's conceptions: (1) the nature of mathematics, (2) the nature of mathematics teaching, and (3) the learning of mathematics, but they were constructed to reflect the teaching of mathematics along a continuum with social interactions at one end and student mastery of rules and procedures at the other end. According to Van Zoest et al. (1994, p. 44), the survey had been implemented on 175 preservice teachers and a factor analysis was carried out on the data collected. There was one single factor only – the socio-constructivist orientation – hence the viability of the BTM instrument in reflecting the social constructivist perspective held by student teachers.

A careful study of the belief items confirmed that there were a variety of beliefs, but overall, they could cover the three conceptions stated above – which I consider appropriate to reflect a particular teaching orientation or instructional practice. Furthermore, each item was culture-free – did not create any cultural problems or culture gap between Hong Kong and the United States, where Van Zoest et al. (1994) implemented the survey and established its viability. The face validity of the survey was achieved by working through the items with my Chinese colleagues (including my critical friend) and with piloting the instrument on a sample of my Chinese students and colleagues in the Mathematics Department of HKIEd. I also invited a translator to convert each belief item from English to Chinese and ensured there was no change in the meaning of the items in Phase II implementation of my study. Moreover, I had full confidence in managing the responses to a Likert scale (in a computer) and performing an analysis on them. I believed that such a questionnaire was appropriate for use in my study.

My Beliefs About Teaching Mathematics questionnaire (Appendix 3C, pages 320-322) was thus adopted from the Beliefs About Teaching Mathematics Survey designed by L. R. Van Zoest, 1993 (personal communication, October 21, 1997). The BTM survey was a 33-item instrument designed to assess beliefs about mathematics teaching. All student teachers were to respond to each item on a five-point Likert scale ranging from "strongly disagree" to "strongly agree". The statements included in the beliefs survey were written to assess teaching qualities on a continuum – a "socio-constructivist orientation" (Van Zoest, Jones, & Thornton, 1994, p. 44) at one end and a performance-driven orientation at the other extreme.

The average of the responses to all the 33 items of the BTM and the standard deviation were employed to give an overall picture of my class of student teachers' orientation to social constructivist teaching. (Methods in calculating the mean will be explained in the paragraphs to follow.) The survey was implemented twice – before the module began on 16 February 1998 in the first meeting and after the module had ended on 22 June 1998 in the last meeting – in order to compare student teachers' beliefs prior to and after my teaching. Overall average scores obtained in these two rounds were compared. In addition, class members' mean scores to individual items and the corresponding standard deviations were also compared to determine the differences in student teachers' beliefs before and after my methodology class (for according to Van Zoest et al., 1994, p. 47, the spread of scores – variation in beliefs – could be more clearly reflected in the standard deviations of individual items than in the standard deviation of the overall scores).

The five Likert scales from "strongly disagree" to "strongly agree" were converted to the numbers "1" to "5" respectively after student teachers' responses had been collected. The gradual increase in the number was an indication of the shift from the extreme end of the content-performance orientation to the opposite end of the learner-focused and social interaction perspective. The greater the number, the stronger the social constructivist stance.

Furthermore, some of the items were designed to reflect the content-focused end of the teaching continuum. Item 4, for instance, stated that "acknowledging multiple ways of mathematical thinking is inefficient and may confuse children" – which emphasised a teaching belief contrary to that of the constructivists. Responses to these items (namely, items 4, 7, 9, 10, 11, 13, 14, 18, 19, 22, 23, 24, 27, 31 and 34) were reversed before the means were calculated. For instance, a response of a "1" to item 4 would be converted to a "5" in the calculation in order to reflect the particular respondent's socio-constructivist viewpoint about teaching. Similarly, a "2" to item 4 would be converted to a "4" in the calculation of the mean. Therefore, a high mean score indicated that student teachers positioned themselves nearer to the socio-constructivist end of the teaching orientation continuum.

The BTM survey data was entered into a computer file for calculating the means and the corresponding standard deviations; the latter served as an indication of the spread of the data. Missing responses in an item would be allocated a "3" because it was the mid-range value of the five scores.

The Interview Schedule (INT)

To clarify the BTM questionnaire responses and to cross check student teachers' beliefs about mathematics teaching, I adapted the 10-question-interview schedule designed by Van Zoest et al. (1994, p. 44) and used it for interviewing the selected Case-97 trainees. All the questions were appropriate for a mathematics lesson as well as for the number project on which Van Zoest et al. were working. Thus, I retained all the 10 questions, but replaced the term "number project" in the items to "mathematics lessons" (Appendix 3D, page 323).

Because of the time and human resource constraints, the interview schedule (INT) was implemented during the non-teaching week, that is, after the methodology class had finished. Only the three selected student teachers S1, S2 and S3 were interviewed, and the conversations (in Chinese) were audio taped. Each interview took about an hour; the dialogue was then transcribed.

The General Teaching Sequence (GTS) Questionnaire

In addition to determining the orientation of all my student teachers towards teaching, I also wished to discover their viewpoints about the general teaching sequence – for instance, a constructivist approach in mathematics lessons and specific teaching methods for handling concepts, principles and skills. A questionnaire (Appendix 3E, page 324) was thus constructed and administered to all student teachers in the first class meeting and in the final one.

This questionnaire on individuals' ideas about the general conduct of a mathematics lesson (GTS) was based on one created by Selkirk (1984, p. 57). It requested student teachers to briefly summarise the different sequences of activities they would like to plan for their pupils in a mathematics lesson and the frequency of employment of each sequence. These sequences were chosen from a wide variety of different lesson formats they would like to use in their actual teaching. Some examples were given to guide student teachers in their responses. For instance, for a particular lesson, the lesson format could be "teacher introduction, pupil exercise and teacher summary".

To compare the effect of my teaching on my student teachers' beliefs, the GTS questionnaire, resembling the BTM survey, was also implemented twice – at the beginning of the first "lecture" and after the module came to an end. In the first meeting, student teachers were asked to articulate their own ideas on the given GTS questionnaire. Different formats for a mathematics lesson were categorised, labelled with a short description or a phrase describing the particular sequence, and the number of responses was counted under the various descriptions. A frequency table was constructed. In the final meeting, student teachers completed the GTS questionnaire again, and responses were again classified and frequencies for each class found – they were compared to the results obtained in the first round.

Journal Writing (JWW)

In every class meeting and before the teaching practice, student teachers were expected to describe the different methods to teach particular topics in junior secondary mathematics by means of a social constructivist model, as explained earlier in this chapter (pages 80-85). Student teachers were asked to follow the instructions stipulated in the worksheet and hence they would first write down their own ideas of teaching about a particular topic, and then in the latter part of the lesson, their reflection about the teaching ideas. Sometimes they were also requested to comment on the arrangement of group discussions and whole class discourse. The "journals", written in Chinese, were collected at the end of the class meeting and analysed. As in the case of the GTS questionnaire, the responses were descriptions and hence they were treated similarly – responses of a similar nature were categorised and labelled, and a frequency table of responses to each category was constructed. The results of the analysis assisted in cross checking results obtained from student teachers' responses, which included those of S1, S2 and S3 to the BTM survey and to the GTS questionnaire, as well as from the critical friend's observations, and from my field notes and reflection.

Teaching Practice Observation and Post-Lesson Discussion

Regarding teaching practice observations, as mentioned earlier in this chapter (pages 86-88), I was only able to visit the three outstanding student teachers S1, S2 and S3. I paid a friendly visit to each one of them in their teaching practice school during their field experience in April and May, 1998. Their teaching performance was recorded in the form of teacher activities, duration of each activity and examples used. Immediately after the lessons, I discussed my notes with them – aiming at comparing their stated teaching beliefs, the general teaching sequence and the specific teacher activities with the observed classroom behaviour.

Collecting Data on the Social Constructivist Learning Environment

Descriptive data from student teachers' journals (JWW) informed the social constructivist learning environment (in addition to student teachers' teaching approaches) and this has been explained in the previous subsection in this chapter (page 95). In this subsection, I will depict the only remaining instrument – the Constructivist Learning Environment Survey, which was included to provide evidence of a constructivist classroom. This instrument was administered in the last meeting on 22 June 1998.

The Constructivist Learning Environment (CLE) Survey

The design of this instrument was based on the new Constructivist Learning Environment Survey (CLES) (P. C. Taylor, personal communication, October 29, 1997). According to P. C. Taylor et al. (1997), the new version of CLES (student form) was designed to obtain measures of students' perceptions of the frequency of occurrence of five dimensions of a constructivist learning environment: (1) personal relevance of learning to students' experiences, (2) uncertainty – opportunities to learn that scientific knowledge is evolving, and that this knowledge is culturally and socially determined, (3) critical voice – learning to question teachers' pedagogical plans and actions that affect students' learning, (4) shared control – learning to control the learning environment, and (5) student negotiation – opportunities for students to explain and to justify to other students their newly developed ideas, to listen attentively and reflect on the viability of others' ideas, and subsequently, to reflect on their own ideas (pp. 295-296).

This new CLES had been implemented in both small-scale qualitative studies and large-scale quantitative studies in science and mathematics classrooms in western countries, and there was substantial evidence to support the finding that CLES can be used to monitor the development of constructivist learning environments in school science in western cultures (P. C. Taylor et al., 1997, p. 300). In action research in particular, P. C. Taylor et al. (1997) claimed that CLES could yield rich profiles of selected students "to enrich the teacher researchers' understandings of the impact on students of their teaching innovations, and alert them to the possible counterproductive impact of their reform endeavours" (p. 300). The robustness and viability of the new CLES and the paucity of literature on a constructivist environment in mathematics teacher education in Hong Kong led to my decision in adapting it as a quantitative instrument in my study.

My Constructivist Learning Environment (CLE) survey (Appendix 3F, pages 325-327) was based on the new CLES (student form). The new CLES contains 30 items altogether, with six items grouped under the five dimensions, but a different phrase was used to represent each dimension. Some of these phrases had been changed in my CLE survey. "Personal relevance" to science, which appeared as "learning about the world" in CLES, was changed to "learning about secondary pupils' learning" – which had a similar meaning, but the context had been changed to my methodology class instead of the science classroom. The six corresponding items were reworded accordingly. P. C. Taylor et al. (1997, p. 300) regards the new CLES as robust enough to allow minor changes to wordings without affecting the instrument's validity. Similarly, "uncertainty", which appeared as "learning about science" in CLES, was changed to "learning about methodology", and the six corresponding items were reworded as well. The remaining groupings of items under various headings, wordings in each item, and each of the five response scales: "almost always (5)", "often (4)", "sometimes (3)", "seldom (2)" and "almost never (1)" had all been adopted without amendments. Table 3.6 compares the wordings in the five dimensions used in CLES and in my CLE survey.

All student teachers were requested to respond to the CLE survey in the final class meeting. It was believed that student teachers could have an overall impression of my teaching only after the whole module had finished, although student teachers' journals collected from class meetings when the module was in progress could have already reflected my management of the constructivist classroom.

Table 3.6
The Wordings Used in Grouping the Items in the New Constructivist Learning Environment Survey CLES (Student Form) and in My CLE Survey, Phase I, 1997-98

	Dimension of constructivist learning environment	Corresponding phrase in the new CLES (student form)	Corresponding phrase in my CLE survey
1.	Personal relevance	Learning about the world	Learning about secondary pupils' learning
2.	Uncertainty of science	Learning about science	Learning about methodology
3.	Critical voice	Learning to speak out	Learning to speak out
4.	Shared control	Learning to learn	Learning to learn
5.	Student negotiation	Learning to communicate	Learning to communicate

Scores from my CLE survey were entered into a computer file and for each group of responses, an average and a standard deviation were calculated. High scores were evidence of a social constructivist learning environment, and because item 6 was worded to refer to the presence of a non-constructivist environment, scores of this item were reversed before the means were found.

In this section, I have described and explained the type of data to be collected and how and when it will be obtained, recorded and analysed. As most of the data collection processes were incorporated into my teaching, the following section will provide the timeline for the implementation of the various instruments in terms of the dates of the class meetings.

PHASE I: IMPLEMENTATION TIMELINE

Table 3.7 summarises the schedule for collection of data in Phase I. To compare the effect of the constructivist approach on the 2SC-97 students, quantitative data were derived from the BTM and the GTS questionnaires, which were applied twice, once before the module began and once after it ended. The evaluation questionnaire CLE which also generated quantitative data was implemented only at the end of the module.

Table 3.7
Data Collection Time in Phase I (1997-98) Implementation

	Instrument			
	Name	Abbreviation		Time for data collection
1.	Beliefs about teaching mathematics survey	BTM	•	First meeting and last meeting
2.	General teaching sequence questionnaire	GTS	•	First meeting and last meeting
3.	Journal writing	JWW	•	Ongoing – before class assessment
4.	Teaching practice observation and discussion	--	•	Field experience
5.	Classroom learning environment survey	CLE	•	Last meeting
6.	The interview schedule	INT	•	Non-teaching week

The remaining data collection methods provided verbal descriptions. My students' journals (JWW) provided ongoing data; my observations on the three outstanding teachers were conducted during student teachers' field experience; and the INT was conducted during the non-teaching week.

Table 3.8 integrates my teaching schedule with the data collection activities in this phase of implementation, and the specific dates for data collection are shown – to facilitate both my teaching and the administering of the data collection instruments.

The GTS and BTM were administered twice – on 16 February 1998 and on 22 June 1998, while the CLE survey on 22 June 1998 alone. Descriptive data from student teachers' journals was obtained between 23 February 1998 and 30 March 1998 – before the teaching practice and class assessment. During the teaching practice in April and May, observation data as well as dialogues with each of the three outstanding student teachers were obtained, whereas interviews were solicited during the non-teaching week in June.

The Phase I data was analysed and interpretations were verified against one another. Based on confirming and particularly disconfirming evidence, changes in Phase II teaching and data collection were made. A summary of the related changes in 1998-99 will be given in the next section; the more detailed results and explanations for the changes will be given in Chapter Four (pages 114-183).

Table 3.8
The Schedule for Class Meetings and Data Collection Activities in the Academic Year 1997-98 (Phase I Implementation)

Date (Monday)	Class Meeting		Data Collection Activities (Phase I) by
16 Feb 1998	1	•	Questionnaires: • General teaching sequence (GTS) • Beliefs about teaching mathematics (BTM)
23 Feb 1998	2	•	Student teachers' journals (concept teaching)
2 Mar 1998	3	•	Student teachers' journals (concept teaching)
9 Mar 1998	4	•	Student teachers' journals (concept teaching)
16 Mar 1998	5	•	Student teachers' journals (skill teaching)
23 Mar 1998	(School visit before field experience)		
30 Mar 1998	6	•	Student teachers' journals (about classroom learning environment)
20 April 1998 – 22 May 1998	(Field experience)	•	Teaching practice observation and discussion with three student teachers.
25 May 1998	7		
1 Jun 1998	8		
8 Jun 1998	9		
15 Jun 1998	10		
22 Jun 1998	11	•	Questionnaires: • GTS • BTM • Classroom learning environment (CLE)
29 Jun 1998	12 (Non-teaching week)	•	Interview the same three student teachers.
July 1998	(Summer Break)		

PHASE II: IMPLEMENTATION

The action research study in Phase II parallelled the Phase I processes. However, since the methodology class in my study was designed for first-year student mathematics teachers, the old cohort, already promoted to their second year, could not be used again. Instead, a new class of first-year Chinese student teachers taking the same module and belonging to the same course had to be used. Since the first phase study had been implemented in the academic year 1997-98, the second phase study was best implemented immediately after this academic year, and hence the class enrolled in the academic year 1998-99 was the most appropriate for my research purposes. This cohort of student teachers was selected, and as before, the methodology class began in the second semester of 1998-99.

Several changes had been made in Phase II implementation, based on the results obtained in Phase I. Table 3.9 shows the changes in (1) my teaching and (2) data collection methods as compared to those of Phase I, with a brief explanation given for each change. With these various changes incorporated into the second phase study, the actual implementation procedures will be described in a similar manner to those in the Phase I study – under the subsections Phase II teaching, sample details and instrumentation.

PHASE II: MY TEACHING

In this second phase of action research, the general constructivist model, as delineated in Chapter Two (pages 42-47), was retained, but some changes were made with respect to my actual teaching. I had a new cohort of 20 first-year Chinese student teachers who enrolled in the 1998-99 academic year (2SC-98 Class or Class-98). They will be described later in the "Phase II: Sample Details" section in this chapter (pages 108-109).

Table 3.9
Changes in Phase II (1998-99) Implementation Based on the Results Obtained in Phase I (1997-98)

		Phase I	Phase II	Brief Explanation
			(1) My teaching	
1.	Learning materials	Written in English	Translated into Chinese	Assisted learning
2.	Topic for discussion in a class meeting	Several topics – different for different groups	One common topic	Student teachers could focus on a common topic and related issues for discussion
3.	Student self-articulation and reflection	Collected once	A newly designed format for self-articulation and reflection; Collected twice – before group discussion and after self-reflection	This compared beliefs before and after discussion; More guidance could be given
4.	Members of a group	Changed for every meeting	Fixed for the whole semester	Chinese student teachers could have friends but not strangers in their groups – this facilitated discussion
5.	Lecturer intervention and input	Not too often	More frequent – during discussion and at the end of every meeting	The lecturer should act as a facilitator and a mediator
6.	Briefing on assessment	First meeting	After a few meetings	Student teachers were more used to the learning style; Less time spent on explanation; No lot drawing in class to save time
			(2) Data Collection	
7.	All instruments	Written in English	All translated into Chinese	A better understanding of what was asked and hence a more reliable response

Language

The language problem was taken into account. Though all classroom discussions were conducted in Chinese, both the learning materials and the questionnaires were in English. To facilitate better understanding of the content of the materials and questions asked, Chinese translations were prepared before the second phase implementation. A translator was requested to review all the wordings to ensure that both clarity and accuracy had been maintained.

Number of Discussion Topics

In the second phase, the number of discussion topics related to secondary school mathematics teaching was reduced to one in each class meeting. In Phase I, each group of students was assigned one mathematics topic in such a way that no two groups would have the same item for discussion (page 81: "The Period Before Class Assessment" in this chapter). For self-articulation and group discussion, the arrangement was found to be satisfactory; but during class discussion, most student teachers, being inexperienced in teaching, could not immediately contribute views about teaching the topic without having had prior opportunity to consider the matter. At best, they gave passing thoughts only. It seemed impossible for student teachers to give immediate responses to the presenters' ideas probably because the topics were "unfamiliar" to them, and the time for discussing each presentation (about 15 minutes) was short; hence discussion was not very active. In Phase II, therefore, I used the same topic for every group.

As a consequence of the reduction in the number of discussion topics to only one in each meeting in the second phase, my students were able to focus better on a common topic. More time could also be devoted to student teachers' writing up of their own ideas on teaching (20 minutes instead of 10), the groups' summaries of the discussion results on overhead transparencies (a total of 30 minutes instead of 10) and self-reflection (20 minutes instead of 10). More time was also arranged for whole-class discussion and for my input (a total of 40 minutes instead of 15). Table 3.10 shows the time allocation in a typical meeting in 1998-99.

Table 3.10
Time Allocation for the Different Activities in a Typical Social Constructivist Classroom Session, Phase II, 1998-99

Activity	Time allowed (min)[a]
Self-articulation	20
Group discussion	30
Class discussion	40
Self-reflection	20
Total	110

Note. [a]Amount of time was different from those of Phase I study, 1997-98.

A Form for Self-articulation and Reflection

In phase I, very few guidelines had been given to assist student teachers in their self-articulation and self-reflection, and my inexperienced student teachers had difficulty in expressing their prior beliefs about teaching. In particular, student teachers lacked sufficient self-articulation in the following areas: (1) teaching sequence, (2) examples, non-examples (which are often used in association with examples of a given concept – non-examples are not examples of the given concept), and exercises used, and (3) important points to stress. Thus, a table of three columns with the three headings (1) to (3) was designed, and under each heading, instructions were given (see Appendix 3G, page 328, the English translation of the worksheet).

This newly designed worksheet was completed twice by each student teacher in a particular class meeting and was collected twice – before and after group and class discussion – thus allowing me to identify student teachers' thinking prior to and after class discussion. In the first phase, such an arrangement was neglected (see page 82: "The Period Before Class Assessment"). The journals were collected at the end of the class meetings and student teachers had not been required to indicate whether the ideas put down were prior self-articulation or ideas developed as a result of the group and class discussion. This Phase II worksheet hopefully would document student teachers' constructed learning.

Group Discussion, Presentation and Class Discussion

The 2SC-98 students were divided into four groups of five. Again, as in Phase I, a member in each group was chosen as discussion leader as well as a presenter of the groups' teaching ideas in class meetings. Similarly, every one in the group was given a chance to lead the group discussion and to present the conclusion to the Class-98 during the whole class discussion in which I acted as chair. (See pages 80-85 for details.)

However, there were two changes in this discussion arrangement in Phase II – student teachers were not allowed to change groups, and the leader who represented the group and presented the teaching ideas also acted in my place as chair of the whole-class discussion.

It was found in the Phase I study that without adherence to the same group in class, communications within groups was impeded. Having student teachers form themselves into groups and remain in the same groups throughout all class meetings allowed student teachers to familiarise with one another so that they could become "friends". This arrangement not only facilitated small-group discussion in which student teachers could express themselves more freely and openly, but also developed the sense of belonging in the particular group that enabled group members to assist in defending their teaching ideas that were challenged during class discussion. With the presenter as chair of discussion, the debate was more active.

My Input

Since more time could be dedicated to student teachers' self-articulation, and to group and class discussion, I could play a more distinctive role in Phase II teaching as compared to that in Phase I. In Phase I, the critical friend C considered my input impromptu when responding to student teachers' ideas about teaching (see C's role in the subsection "Disinterested Peer/Cooperating Colleague/Critical

Friend" at the beginning of this chapter, pages 74-75), and both student teachers and C expected that I could be more explicit in stating teaching ideas, correcting student teachers' misconceptions and providing the proper teaching methods for student teachers' reflections. Both the facilitator role and the mediator role were strengthened and enforced in the second phase.

Class Meeting Schedule

A class meeting schedule was constructed based on the arrangement of discussion for four groups of 2SC-98 student teachers (see Table 3.11). In this phase of implementation, everything was similar to that of Phase I with a few exceptions.

Table 3.11
The Schedule for Class Meeting in the Academic Year 1998-99 (Phase II)

Date (Thursday)	Class meeting	Activities for class[a]
28 Jan 1999	1	Briefing: Class meetings[b]
4 Feb 1999	2	Teaching of skills
11 Feb 1999	3	Teaching of skills
4 Mar 1999	4	Teaching of skills
11 Mar 1999	5	Teaching of principles
18 Mar 1999	(School visit before field experience)	
25 Mar 1999	6	Teaching of principles Briefing: Assessment[b]
1 April 1999	7	Teaching of problem solving
8 April 1999	8	Assessment: Individual presentation (4 student teachers)
12 April 1999 - 14 May 1999	(Field experience)	
20 May 1999	9	Assessment: Individual presentation (4 student teachers)
27 May 1999	10	Assessment: Individual presentation (4 student teachers)
3 Jun 1999	11	Assessment: Individual presentation (4 student teachers)
10 Jun 1999	12	Assessment: Individual presentation (4 student teachers)
17 Jun 1999	13	Debriefing Module evaluation
21 Jun 1999	14 (Non-teaching week)	Submission of assessment reports
July 1999	(Summer Break)	

Note. [a]Most data collection activities have been included in the class activities. [b]Arrangement in the briefing was different from Phase I, 1997-98.

There were thirteen weeks for teaching – from 28 Jan 1999 to 17 June 1999 in the second phase, whereas in the first phase there were only eleven face-to-face teaching weeks; the Class-98 students met for two hours every Thursday morning.

In the first meeting, unlike that in Phase I, there was no briefing for assessment. Assessment arrangements were deferred until later meetings (the sixth in this case) so that student teachers could become more used to the new style of learning on which the assessment was based. In Phase I, the 2SC-97 students were found to have had difficulty understanding the assessment requirements, and a lot of time was spent explaining what was needed. Moreover, the lot drawing also took much time, and I decided to draw the lots after the class meetings – those interested to witness the results of lots were invited to attend. In so doing, the precious time saved could be used more appropriately by responding to and answering students' queries about the assessment.

However, assessment in the form of individual presentations had to start before the teaching practice in order to allow a longer period of time (each student teacher was given about 25 minutes) for self-expression, explanation and defence.

Before individual student teachers' assessment, the sequence of teaching followed that in Phase I. A similar worksheet was used (providing one common mathematics topic for the whole class as well as guidelines for self-articulation and reflection, as mentioned earlier in this chapter, pages 103-104).

The journals about teaching ideas, both before discussion and after discussion, were collected. Results obtained were analysed and made known to my students in the next meeting; meanwhile, the journals were returned to my students for their perusal and reference.

Assessment in the form of a presentation was conducted from 8 April 1999 before the teaching practice, and continued after the teaching practice. The procedure employed in Phase I was followed in Phase II. In the last meeting, the 2SC-98 students were similarly debriefed, and reports of planned teaching strategies were collected in the non-teaching week.

PHASE II: SAMPLE DETAILS

In this second phase of study, there was another cohort of student teachers.

The new cohort of 20 first-year students was enrolled in 1998-99. Similar to the cohort in Phase I, students (2SC-98 Class or Class-98) in this phase were again mathematics elective students taking the same course and the same module; they were young Chinese, and again without any teaching experience. However, 9 of them were female and 11 male. (See Table 3.12.)

Table 3.12
Demographic Details of Student Teachers Participating in Phase II Study, 1998-99 (N = 20)

Characteristics	N[a]
Course	
Certificate in Secondary Education (Chinese) Course (Two-year Full-time)	20
Gender	
Female	9
Male	11
Age	
19 - 22 years	20
Ethnicity	
Chinese	20
Qualifications	
Pass in Advanced Level Mathematics	20
Teaching Experience	
Nil	20

Note. [a]A different cohort of student teachers from that of the 1997-98 group.

Out of the 20 student teachers, I had invited three with the best academic results in mathematics in semester one, 1998-99, to be involved in the case study. (The rationale underlying the choice of high achievers can be found in the "Research Design" section in this chapter, pages 73-74.) They were E1 (male), E2 (female) and E3 (male) and their personal details as regards gender, academic results and schools in which they were placed for field experience are shown in a table (Table 3.13) similar to that in Phase I. These student teachers were all placed in schools admitting the top primary year six pupils in Hong Kong. Their roles resembled those of the outstanding student teachers in Phase I: they provided information about their learning by completing journals and questionnaires during class meetings, and they agreed to be observed in their teaching practice and to be interviewed in the non-teaching week.

Table 3.13
Particulars of the Three Outstanding Student Teachers in Phase II Study, 1998-99

	Three outstanding student teachers[a]		
Characteristics	E1	E2	E3
Gender	Male	Female	Male
Academic result in mathematics, semester one, 1998-99	Top	Top	Top
School for teaching practice[b]	Band-one	Band-one	Band-one

Note. [a]Different student teachers from the 1997-98 Case. [b]Not the same Phase I schools. Hong Kong secondary schools are divided into five bands: from "band-one, band-two" to "band-five". Primary year six pupils are ranked from top to bottom according to their overall academic results in primary year six. The top 20% of pupils in this ranked list are admitted into "band-one" schools for secondary education, and so on; the bottom 20% in this list are allocated to "band-five" schools.

PHASE II: INSTRUMENTATION

As mentioned earlier in this chapter (pages 102-103, the "Language" subsection), all the questionnaires had been translated into Chinese and vetted by a translator to ensure accuracy in meaning. Both quantitative and descriptive data were then collected following the same method and procedure as in Phase I – to reveal student teachers' beliefs about teaching mathematics and the created social constructivist classroom during my teaching (See Tables 3.5 and 3.7 in the Phase I study, pages 90 and 99 respectively).

As mentioned (see subsection "Class Meeting Schedule" in this chapter, pages 106-108), the data collection activities were generally incorporated into my teaching. To follow and to adhere to the implementation timeline more efficiently and effectively, a schedule (Table 3.14) for class meetings was prepared, as in Phase I, that allowed me to implement my teaching as well as to simultaneously collect data for my research purposes. The GTS and BTM questionnaires were administered in the first and the final meetings (28 January 1999 and 17 June 1999), whereas the CLE survey was administered only in the last meeting. All student teachers' journals were collected during the meetings; additional data was collected from classroom observation and from interviews with the three selected outstanding students in April and May, 1999, and during the non-teaching week around 24 June 1999.

Table 3.14
The Schedule for Class Meeting and Data Collection Activities in the Academic Year 1998-99 (Phase II Implementation)

Date (Thursday)	Class Meeting	Data Collection (Phase II)
28 Jan 1999	1	• Questionnaires: • General teaching sequence (GTS) • Beliefs about teaching mathematics (BTM)
4 Feb 1999	2	• Student teachers' journals (skill teaching)
11 Feb 1999	3	
4 Mar 1999	4	
11 Mar 1999	5	• Student teachers' journals (principle teaching)
18 Mar 1999	(School visit before field experience)	
25 Mar 1999	6	
1 April 1999	7	
8 April 1999	8	
12 April 1999 - 14 May 1999	(Field experience)	• Teaching practice observation and discussion with three student teachers
20 May 1999	9	• Student teachers' journals (about classroom learning environment)
27 May 1999	10	
3 Jun 1999	11	
10 Jun 1999	12	
17 Jun 1999	13	• Questionnaires: • GTS • BTM • Classroom learning environment (CLE)
24 Jun 1999	14 (Non-teaching week)	• Interview the same three student teachers
July 1999	(Summer Break)	

ETHICS

This section describes the precautions – regarding research ethics – I undertook during the entire study.

In the first meeting in each of the two phases of implementation of the present study, I sought student teachers' assistance in my research. I stated clearly to my student teachers that I was only doing research to improve my own practices and that they were not forced to supply any data for my research study, for instance, in writing their journals and in completing the questionnaires. All these data collection activities, though arranged during the class meetings, were optional; they might withdraw from my study at any time they wished. If extra time was required outside a lecture to complete the questionnaires or to attend interviews, permission would first be sought from the student teachers concerned. However, they were reminded that they were required to participate in the related assessment activities – presenting a planned teaching method and submitting a report of the presentation – because the methodology module was compulsory.

Student teachers were also guaranteed that all data obtained was strictly confidential, and any data collected would not be divulged in any way unless I had their permission. In any written responses, although I asked my students to write down their names, the names were only for identification purposes. Symbols, but not names, were used where it was really necessary, for instance, in presenting findings in my thesis. Furthermore, all the written responses would be returned to the student teachers immediately after use. Constructive comments and marking would be given in student teachers' journals and in questionnaires where appropriate, to show approval and encouragement.

Throughout the study, data was stored securely in my computer files. It will be kept for a period of five years beyond the conclusion of the study, after which it will be destroyed. Similarly, qualitative instruments used with the participants were either returned immediately after use or they will be destroyed at the conclusion of the study.

CONCLUSION

In this chapter, I have provided a detailed description of how the two phases of my action research study had been implemented. To conclude the chapter, it is appropriate to summarise the main research activities in the two phases to encompass also those ongoing processes such as data analysis (immediately after my lessons, weekly, and at the end of a stage of my study), literature reviewing and discussion with my critical friend. Table 3.15 is the timetable of the main activities.

The results of the present study are presented and discussed in the next two chapters.

Table 3.15
A Timetable of the Main Activities of the Two Phases of the Study

Month	Activities
	Phase I[a]

February 1998	• Methodology module began (Class-97)
	• Data collection and analysis
	  • Questionnaires (before first lecture)
	  • Journals (ongoing)

March 1998	• Data collection and analysis • Journals (ongoing)

April – May 1998	• Data collection and analysis
	  • Journals (ongoing)
	  • Field experience (Case-97)

June 1998	• Data collection and analysis • Questionnaires (end of module)
July 1998	• Data collection and analysis • Interview (Case-97)
August – December 1998	• Data analysis
	Phase II[a]
January 1999	• Methodology module began (Class-98) • Data collection and analysis • Questionnaires (before first lecture)
February – March 1999	• Data collection and analysis • Journals (ongoing)

April – May 1999	• Data collection and analysis
	  • Journals (ongoing)
	  • Field experience (Case-98)

June 1999	• Data collection and analysis • Questionnaires (end of module)
July 1999	• Data collection and analysis • Interview (Case-98)
August 1999 – August 2002	• Data analysis and writing up of thesis

Note. [a]Data collection, observation, reflection, discussion with my critical friend and literature reviewing were ongoing processes.

CHAPTER FOUR

RESULTS AND DISCUSSION (PHASE I)

INTRODUCTION

In order to determine if my social constructivist approach could be employed on preservice teachers in my workplace, I commenced studying a methodology class of first-year Chinese student mathematics teachers in the (northern) spring of 1998, concentrating on the creation of a social learning environment to facilitate student teachers' construction of knowledge about mathematics teaching. Results obtained from teaching the methodology module, which ended in June 1998, were used to improve my teaching in the spring of 1999 – on a different class of first-year Chinese student mathematics teachers enrolled in the same course.

The main purpose of the study, as stated in previous chapters, was to investigate the prior knowledge about teaching mathematics held by first-year student teachers, and whether these beliefs could be altered by social interactions among the learners and with me, the facilitator and the mediator of learning. In other words, my action research tried to study two main issues: (1) beliefs about mathematics teaching held by student teachers, and (2) the social constructivist learning environment developed in a class of Chinese learners.

In this chapter and the next, I will report and discuss the results obtained during the two phases of implementation of action research under the two broad issues just mentioned. Phase I results, particularly those leading to changes in the Phase II implementation, will be dealt with first in this chapter. In the following chapter, the Phase II findings and an overall evaluation of the study will be reported.

PHASE I – STUDENT TEACHERS' TEACHING BELIEFS

Beliefs about mathematics teaching held by the class of student teachers in Phase I (hereafter referred to as 2SC-97 Class or Class-97) were identified through their responses to the Beliefs About Teaching Mathematics (BTM) survey, the General Teaching Sequence (GTS) questionnaire, and their journal records (JWW) during the period of the methodology module. (The questionnaires can be found respectively in Appendices 3C, pages 320-322; 3E, page 324 and 3B, page 319.) Furthermore, three outstanding students, S1, S2 and S3, were chosen from the (same) Class-97 to form a case study group (hereafter referred to as Case-97; see Chapter Three, pages 86-88). Their teaching beliefs, on the other hand, were explored not only through the foregoing instruments but also through an Interview Schedule (INT) (the interview schedule can be found in Appendix 3D, page 323), and by observing their lessons, followed by a post-lesson discussion during the teaching practice. Responses from Case-97 members (as well as discussion with my critical friend C) allowed me to have a more in-depth understanding of case members' beliefs, particularly with respect to both their professed teaching beliefs before and after the methodology module, and their actual classroom practices.

In this section, I will first discuss beliefs about mathematics teaching held by all Class-97 members. To avoid ambiguity and misunderstanding, hereafter Class-97 or 2SC-97 Class always includes the three Case-97 students because they were also members of Class-97. I will present Class-97 members' results of the BTM survey and of the GTS questionnaire conducted at the beginning of my methodology class (hereafter referred to as pre-module results), then I will discuss the results collected from all the students' journals (JWW) which they recorded during the methodology sessions. Next, I will present and discuss the results of the BTM survey and of the GTS questionnaire administered again at the end of my methodology module (hereafter referred to as post-module results). Lastly, I will discuss the teaching beliefs of individual members of the Case-97 alone.

Results from the BTM Questionnaire (Pre-module), 1997-98

There were 23 student teachers present on the first day of the methodology class during which I administered the 33-item BTM questionnaire (the questionnaire can be found in Appendix 3C, pages 320-322). As completion of the questionnaire was voluntary, only 15 students (including the three Case-97 students) completed and returned it – representing a response rate of 65%. Student teachers' responses were analysed in two different ways:

(1) The overall mean agreement score for all the 33 items in the BTM questionnaire indicated the generally held orientations to teaching mathematics.

(2) The responses were categorised based on the interview questions (INT) to probe more deeply into the different kinds of beliefs about teaching mathematics possessed by the 2SC-97 students. (The INT can be found in Appendix 3D, page 323; the nine categories can be found later on pages 118-119).

Appendix 4A (pages 329-330) records in tabular form (1) the overall mean agreement scores (and the standard deviations) by members of the Class-97 (which included the Case-97 students) and of the Case-97 alone, (2) the mean individual item scores (and the corresponding standard deviations) by Class-97 members (which included the Case-97 students), and (3) the individual item scores by the Case-97 students. Items marked with an asterisk were constructed in the content-focused sense and scores for these items were reversed and recorded in the appendix. The mean scores and corresponding standard deviations were calculated based on the "reversed" scores of marked items and true responses to unmarked items.

2SC-97 Overall Teaching Orientation (Pre-module)

The BTM questionnaire made use of a five-point Likert scale ranging from 1, which represented "strongly disagree", to 5, which represented "strongly agree". A value of 3 meant "undecided". In interpreting the mean, a high score (3.5 or above) for an item in the questionnaire indicated a more learner-focused orientation in organising teaching; a low mean score (less than 2.5) indicated a content-performance orientation with an emphasis on learners' performance. In between these two orientations, a mean score less than 3.5 but no less than 2.5 indicated a content-understanding orientation with an emphasis on conceptual understanding (see interpretation by Van Zoest et al., 1994, pp. 42, 44, 47). Table 4.1 summarises the interpretations of different mean scores.

Table 4.1
The Correspondence between an Agreement Response, the Mean Score and the Teaching Orientation

Agreement response	Mean score	Teaching orientation
"Strongly agree"	mean score ≥ 4.5	Learner-interaction
"Agree"	4.5 > mean score ≥ 3.5	Learner-interaction
"Undecided"	3.5 > mean score ≥ 2.5	Content-understanding
"Disagree"	2.5 > mean score ≥ 1.5	Content-performance
"Strongly disagree"	1.5 > mean score	Content-performance

As stated in Chapter Three (page 91), Van Zoest et al. (1994) factor-analysed the BTM survey (from which the BTM questionnaire used in this study was adopted) and identified only one significant factor in all the items – the socio-constructivist teaching orientation. Thus in this study, an overall mean of the 2SC-97 students' responses (which included responses by the Case-97 students because they were members of the 2SC-97 Class) to all the 33 items was calculated to indicate student teachers' overall orientation to teaching mathematics. For comparison and analysis, the overall mean score of each Case-97 student to all items was also calculated and tabulated. Table 4.2 (see also Appendix 4A, pages 329-330) shows the overall average agreement scores for the BTM questionnaire for Class-97 members and for the Case-97 trainees.

Table 4.2
The Overall Mean Agreement Scores for the Beliefs About Teaching Mathematics (BTM) Survey (Pre-module) in Session 1 (16 February 1998) Before the Module Began, Phase I, 1997-98 (N = 15)

		Case-97[b]		
	Class-97[a]	S1	S2	S3
Pre-module				
Mean	3.6[c]	3.7[c]	3.7	3.5
SD	1.0	1.2	1.0	0.9

Note.
Responses were made on a 5-point scale (5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, 1 = strongly disagree).
[a]15 returns out of 23. [b]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the class total. [c]S1 gave no response to item 30.

The overall mean of 3.6 (SD 1.0) scored by the class of 2SC-97 students and the similar values scored by the Case-97 students (3.7, 3.7 and 3.5 and SD 1.2, 1.0 and 0.9 respectively) indicated a slightly more learner-focused teaching orientation (according to Van Zoest et al., 1994, pp. 42, 44, 47; see also Table 4.1, page 117). It follows that the apparent prior belief of the 2SC-97 students was that mathematics teaching should emphasise personal construction of knowledge through social interaction. However, the standard deviations of the whole class and of members of the Case-97 (approximately 1.0) showed that there was variability in the scores of individual items (according to Van Zoest et al., 1994, p. 47). The second part of the analysis (as mentioned previously, page 116) provides a better understanding of student teachers' prior beliefs. This will be reported in the subsection to follow.

2SC-97 Different Teaching Beliefs (Pre-module)

For a more in-depth study of my student teachers' beliefs about teaching mathematics, I further analysed results from the BTM questionnaire by grouping items of a similar nature into nine categories – according to what was asked in the INT (Appendix 3D, page 318). The nine categories of beliefs were: (1) the role of mathematics teacher; (2) the use of questioning in class teaching; (3) the amount of mathematics content to be taught to the pupils and the sequence of its presentation; (4) problem solving; (5) the use of group interaction in mathematics learning; (6) the effect of teacher exposition; (7) the role of personal construction of mathematical ideas; (8) teaching and learning of mathematics; and (9) teacher change.

Appendix 4B (pages 331-333) shows the 2SC-97 student teachers' pre-module agreement responses to the items in the BTM survey classified under the nine categories described above. For each item in a category, an average score (and the corresponding standard deviation) by all the students in Class-97 (which included the three outstanding students) was calculated. Individual Case-97 members' scores were also computed and tabulated for comparison and analysis. Items constructed in the content-focused sense (marked with an asterisk) had their scores reversed.

(1) Role of a Mathematics Teacher

At the beginning of the methodology module, the 2SC-97 students (including the Case-97 students) supported the proposals that a mathematics teacher should encourage pupil learning (item 1) and create a non-threatening learning environment (item 6). In other words, the whole class agreed that the key responsibility of a teacher was to be a facilitator who tried to encourage pupils to explore their own mathematical ideas.

(2) Questioning

The 2SC-97 students and the Case-97 trainees both agreed that questioning could challenge their pupils' existing mathematics ideas and thinking, and that persistent questioning could perturb prior knowledge and consequently would lead to mathematical learning.

(3) Mathematics Content

The belief statements under the "mathematics content" category were all constructed in the content-focused sense and scores recorded in Appendix 4B (pages 331-333) had been reversed.

Responses to the three items under this category ranged from "disagree" (item 32, with scores reversed) to "undecided" (items 18 and 26, scores for both items were reversed). It appeared that the 2SC-97 students believed that mathematics content should be presented to their pupils in the correct sequence (item 32, with scores reversed), but they seemingly could not decide whether they should follow the textbook sequence or not (item 18, with scores reversed). Also, they could not decide whether there was a fixed amount of mathematics to be taught (item 26, with scores reversed).

In this respect, members of the Case-97 also agreed (and S2 agreed strongly) that it was important to present the mathematics content in the correct sequence (item 32, with scores reversed). However, in contrast to the Class-97 students as a whole, they (with S2 undecided) further supported that there was a fixed amount of mathematics content to be covered at each grade level (item 26, with scores reversed). Yet, like the whole class, the Case-97 students also could not decide whether the textbook sequence should be followed or not (item 18, with scores reversed).

Judging from student teachers' responses to this category of items, it can be inferred that their prior beliefs about mathematics teaching appeared to be rather content-focused. They thought there could be a correct sequence in teaching mathematics, but they could not decide (1) whether there was an established amount of mathematics that should be taught, and (2) whether the teaching sequence could probably be provided in mathematics textbooks.

(4) Problem Solving

Overall, Class-97 members "agreed" with all the items within the "problem solving" category (scores for items 10 and 23 were reversed). It appeared that the students believed that a mathematics teacher's vital task was to motivate his or her pupils to solve their own mathematical problems (item 5), and that the teacher's main function was not necessarily to provide clear and concise solutions (items 10 and 23, both with scores reversed), but to create opportunities for pupils to face challenges in order that learning could occur (item 29).

Similar to the class, the Case-97 study group also agreed (and S1 strongly) that a teacher should motivate the pupils in solving the problems (item 5), but it deviated from the class opinion for the other three items, namely, items 10, 23 and 29. The idea of providing solutions to problems (item 10, with scores reversed) received different responses from the Case-97 students: S1 agreed, S3 disagreed, and S2 was unsure. While both S1 and S2 agreed that it might not be necessary for a teacher to provide the children with clear and concise solutions (item 23, with scores reversed), S3 was indecisive. Similarly, S3 expressed uncertainty when considering the provision of more difficult problems for his pupils (item 29), while S1 and S2 agreed with this idea.

(5) Group Interaction

Class-97 members also showed "agreement" to all the items in this category (scores for item 12 were reversed). They all agreed that working on interesting problems in small groups facilitated mathematics learning (item 19). They also agreed that mathematics might not be best learnt individually (item 12, with scores reversed), but would be best learnt if pupils were given opportunities to discuss among themselves (items 27 and 31), and to reflect on and evaluate their own learning (item 25).

The three student teachers in Case-97 were not unanimous in their views on group learning. S1 agreed that group interaction facilitated learning (items 19, 25, 27 and 31), but believed that mathematics was best learned individually (item 12, with scores reversed). S2 supported group learning (items 19, 25 and 31), but was not sure whether it was better than learning alone (items 12 and 27, where scores for item 12 were reversed). S3, though, supported learning in groups (items 12, 19 and 25, where scores for item 12 were reversed), and challenged the idea that pupils could learn more mathematics by working together and by discussing among themselves (items 27 and 31). In brief, Case-97 members had mixed beliefs with respect to the importance of group interaction in mathematics learning. While S3 was generally undecided about the effect of group learning, both S1 and S2 were positive in this respect.

(6) Teacher Exposition

In this category, belief statements were all constructed in the content-focused sense and hence their scores were reversed.

While concurring with the idea that opportunities for group work, group discussion and self-reflection could lead to effective mathematics learning (as seen in the previous paragraph), the 2SC-97 students supported the proposal that follow-up instruction would correct pupils' difficulties in learning after understanding their pupils' problems (item 21, with scores reversed). However, it was surprising that the 2SC-97 students were indecisive as to whether the expository method of teaching was effective or not (items 11, 22 and 30, with all scores reversed).

The Case-97 students' responses indicated those students' different views about expository teaching. S3 disagreed that teacher exposition was the most effective way for pupils to learn mathematics (items 11, 22 and 30, all with scores reversed); and he also disagreed that direct instruction would correct pupils' errors and facilitate learning (item 21, with scores reversed).

S1 showed signs of possessing contradictory ideas about expository teaching. Similar to S3, her response to item 11 (with scores reversed) showed strong disagreement with the claim that "pupils listening to the teacher explaining" was the best way to learn mathematics. She also doubted if exposition was the best teaching method (item 30, with scores reversed). At the same time, she agreed that telling the answers to students would "correct difficulties" (item 21, with scores reversed) and could be an efficient way of facilitating learning (items 22, with scores reversed).

S2 also displayed his apparent inconsistent beliefs about teaching by telling. He thought that the most effective way to learn mathematics was listening to the teachers' explanation (item 11, with scores reversed). However, similar to S3, he did not believe that direct instruction could facilitate learning and correct pupils' difficulties (items 21, 22, all with scores reversed); he also doubted the use of the expository method in presenting mathematical material (item 30, with scores reversed) – a belief held by S1.

Overall, there were differences in teaching beliefs among student teachers in the class with respect to the effectiveness of the transmission model as reflected in the standard deviations – all greater than one – for all the items grouped in this category.

(7) Personal Construction

The 2SC-97 students "agreed" with nearly all the eight belief statements (except item 4) under this category (scores for items 4, 7 and 17 were reversed). These student teachers seemed to support the idea that their pupils should have developed different mathematical ideas and thinking and that teachers should listen to, accept and acknowledge alternative ideas and different ways of solving a problem. If these student teachers accepted that pupils constructed their own mathematical knowledge, it is logical to argue that the student teachers should also acknowledge multiple perspectives held by their pupils; however, their responses to item 4 were negative.

Item 4 (with scores reversed) concerned the effectiveness of acknowledging multiple ways of mathematical thinking. An average of 3.1 (SD of 1.0) for this statement indicated that the student teachers in Class-97 were doubtful about this. For the Case-97 study group, only S1 agreed with this statement, S2 could not decide and S3 disagreed (scores for item 4 were reversed). The different views to a single item within a belief category was another indication of the contrasting beliefs evident among these students.

There were other items that received different responses from members of the Case-97 under this category. S1, for instance, accepted that pupils could have different mathematical thinking in general (see scores for items 2, 7, 8 and 15; scores for item 7 were reversed), however, it was surprising that she was indecisive when asked to choose between ignoring or accepting her pupils' own explanations and justifications which sounded ridiculous (items 17 and 33; scores for item 17 were reversed). As indicated previously, S1's beliefs fluctuated considerably.

Fluctuations in the beliefs held by S2 and S3 could also be implied from the scores of these students.

(8) Teaching and Learning Mathematics

Student teachers' responses to the items regarding the nature, the teaching and the learning of mathematics varied from "undecided" (for items 9, 13 and 24; scores for item 9 and 13 were reversed) to "agree" (item 16) and "strongly agree" (item 28). Class-97 members agreed that effective mathematics teachers should themselves enjoy both learning and doing mathematics (item 16). This can be interpreted as showing that the students have an awareness that their own attitude towards and interest in mathematics can have impact on their students. A significant point to note is that Class-97 members' mean score for item 28 was 4.5 (one of the two items with the highest mean score). Agreeing strongly that "it is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other" showed that the 2SC-97 students believed that mathematics is a coherent body of concepts and skills. However, on the other hand, these students' responses to item 13 (with scores reversed) showed that they could not decide whether mathematics was made up of unrelated topics – contrary to their responses to item 28. This probably demonstrated that the 2SC-97 students had no clear idea about the nature of mathematics.

The two other beliefs which Class-97 members were unsure about were:

- whether mathematics learning should involve a lot of memorisation (item 9, with scores reversed); and
- whether mathematics problems could be solved without using rules (item 24).

As for the Case-97 students, they either agreed, or had trouble in deciding whether they should agree or not to the statements that mathematics learning should involve memorisation (item 9, with scores reversed), and that mathematics problems could be solved without using rules (item 24). However, two students (S1 and S2) in the Case-97 study group were certain that mathematics was not made up of unrelated topics (item 13, with scores reversed; see also item 28) – which was contrary to the Class-97 students' belief.

Student teachers' problems thus identified from these findings had already been noticed by my critical friend C, who remarked that my students did not seem to have a thorough understanding of the mathematics they were being prepared to teach (see later section "Phase I – Critical Friend C's Comments" in this chapter, page 171).

(9) Teacher Change

Only one item in the survey concerning teacher change. This item seemed irrelevant in the pre-module survey, because the 2SC-97 students had not yet had a chance to experience any mathematics class teaching, and hence responses could only be speculative. According to the mean score of 3.5 (with a SD of 0.6), I assumed that my students (with the exception of S1 and S3, who could not decide at all) believed that they might develop an attitude of inquiry after their field experience in March to May.

Summary (Pre-module BTM Results, 1997-98)

Analysis of the BTM results infers that the 2SC-97 students considered themselves facilitators of mathematics learning (see "2SC-97 Overall Teaching Orientation (Pre-module)", pages 117-118; Category 1, page 119; Category 2, page 119; Category 4, pages 121-122; Category 5, page 121; and Category 7, pages 123-124). However, they considered it paramount to teaching mathematics by following a correct order, although they were unsure of the amount of content to be taught as well as the correct sequence to follow (see Category 3, page 120). These student teachers might have been so uncertain in their mathematics knowledge (Category 8, pages 124-125) that they lacked the confidence to resolve this mathematics content and sequence problem.

Furthermore, though the 2SC-97 students supported the idea that questioning, group discussion, self-expression and evaluation were all vital learner-focused activities that could assist personal and social construction of mathematical knowledge, it was striking to me that they still demonstrated ambivalence as to the effectiveness of the transmission model of teaching (Category 6, pages 122-123). This may be the reason why the teaching orientation they displayed in the pre-module BTM survey was only slightly more inclined to the learner-focused end of the teaching continuum (page 118 in "2SC-97 Overall Teaching Orientation (Pre-module)"). Moreover, there was a variation in their teaching beliefs (as shown by a SD of 1.0).

Results from the GTS Questionnaire (Pre-module), 1997-98

At the start of the module and on the same day (i.e., 16 February 1998) that the BTM questionnaire was administered, student teachers were asked to describe, through an open-ended questionnaire (GTS) (which can be found in Appendix 3E, page 324), the general teaching sequence(s) (more than one teaching sequence was acceptable) that they would like to use in their future teaching. Again, there were 15 returns (including the three Case-97 trainees: S1, S2 and S3) out of a class of 23 students. There were only two distinctive teaching sequences identified, with S3 writing down two methods of teaching. Among the responses, 12 (80%) were similar, suggesting a sequence comprising three stages: (1) teacher introduction, (2) pupil exercise and (3) teacher conclusion. I interpreted this sequence as similar to the expository approach (see Appendix 4C, Monday, 16/2/1998, page 334). The four other responses (27%) did not actually represent a teaching sequence; rather, student teachers wrote that "a discovery approach" would be used – no elaboration of this approach was given in any of the student teachers' responses. For the Case-97 trainees, S3 wrote both approaches as his response – resulting in the total number of response data in column "n" to exceed 15, which was the original number of returns. S1 suggested the expository teaching sequence (conforming to the sequence proposed by the majority of members of the Class-97), while S2's stated preference was the discovery approach. The results are summarised in Table 4.3.

Table 4.3
The General Teaching Sequence (GTS) (Pre-module) Stated by Student Teachers in Session 1 (16 February 1998) Before the Module Began, Phase I, 1997-98 (N = 15)

Response[a]	Stated teaching sequence	n	%	Response by Case-97[b]		
(1)	Introduction-exercise-conclusion	12	80	S1		S3
(2)	Discovery method	4	27		S2	S3

Note. [a]15 returns out of 23. However, since some students gave more than one preferred teaching sequences (e.g., S3), but some did not give any, a total of 16 responses were obtained. [b]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the calculation.

In the three-stage expository teaching sequence posited by the majority of students of the Class-97 (including the three Case-97 students), the first stage "teacher introduction" probably represented a tendency towards the use of direct teaching, and "pupil exercise" – which constituted the second stage in the sequence – may signal students' emphasis on the mastery of mathematics knowledge. In other words, results in the GTS questionnaire appeared to show that the 2SC-97 students were content-performance oriented rather than the more learner-focused position. This was an interpretation based on their overall responses to the BTM questionnaire. The inconsistent findings from the two questionnaires indicated that these student teachers' beliefs about mathematics teaching were unstable. They held mixed views about teaching – ideas that could have been developed from their experience as school pupils and learnt in other modules they had taken at HKIEd.

Of course, the different findings could also have been brought about as a result of the qualitative or quantitative nature of the two questionnaires constructed for use. The BTM questionnaire, being a structured questionnaire, may, to some extent, influence the respondents – this is often the drawback in using structured questionnaires (Tuckman, 1972, p. 197, p. 214). The GTS questionnaire, on the other hand, requires open-ended responses, and hence student teachers' written descriptions would more likely reflect their real thinking.

The next subsection presents an analysis of the responses that student teachers wrote in their journals about teaching specific mathematics topics in junior secondary schools.

Results from Student Teachers' Journals: JWW, 1997-98

Journals on teaching a specific mathematics topic were collected from student teachers during four class sessions before their teaching practice period. The student teachers began writing their journals in the second session. The dates of the four class sessions in which journals were collected and the main themes were:

- Session 2 (23 February 1998): Teaching of concepts (concept teaching)
- Session 3 (2 March 1998): Teaching of concepts (concept teaching)
- Session 4 (9 March 1998): Teaching of concepts (concept teaching)
- Session 5 (16 March 1998): Teaching of skills (skill teaching).

Appendices 4D1-4D4 (pages 355-358) show the analysis of the results in the journals collected in the sessions, and Appendix 4C – Monday, 23/2/1998 to Monday, 16/3/1998 (pages 336-341) – also contains my interpretation of student teachers' journal entries.

Though it was optional to submit their journals to me, most of my students did hand in their journals at the end of each class session. The lowest return rate was session 5 on 16 March 1998 in which only 15 out of 23 student teachers handed in their written descriptions (see return rates in Appendices 4D1-4D4, pages 355-358). This represented a 65% return. Responses in the journals for each of the above meetings were categorised and tables were constructed (Appendices 4D1-4D4, pages 355-358). From their journals, I noted that students suggested a variety of teaching sequences for concept teaching and skill teaching, reflecting the knowledge they had constructed during each class session. Resembling the format in Table 4.3 (page 127), Table 4.4 summarises the teaching sequences I have identified from student teachers' journals (note that not all journals included records in which a teaching sequence can be identified, hence these were not included in the table; note also that sometimes more than one teaching sequence was provided by a student teacher.)

It can be seen from Table 4.4 that student teachers became familiar with the names of the various teaching sequences. Overall, direct teaching seemed to be favoured by the Class. The modal teaching sequences that could be identified on 23 February 1998 included both the "exposition" and "discovery" sequences (though only 23% of the returned journals included such information). For the other three sessions, "exposition" was still the mode, and the highest frequency was 87% on 16 March 1998; the number of students suggesting the use of "discovery" was low in each session.

Table 4.4
The General Teaching Sequence (GTS) from Student Teachers' Journals, Phase I, 1997-98

Stated method	n	%	Response by Case-97[a]		
Session 2 (23/2/1998) (concept teaching)[b]					
Exposition	5	23	S1	S2	S3
Discovery	5	23	S1		
Inappropriate/irrelevant teaching method	2	9			
Session 3 (2/3/1998) (concept teaching)[c]					
Exposition	15	65			S3
Discovery	1	4			
Sandwich[d]	4	17	S1		S3
Inappropriate/irrelevant teaching method	8	35			
Session 4 (9/3/1998) (concept teaching)[e]					
Exposition	6	26	S1	S2	S3
Discovery	3	13		S2	S3
ELPS[f]	11	48		S2	
Session 5 (16/3/1998) (skill teaching)[g]					
Exposition	13	87	S1	S2	S3
Discovery	2	13	S1		
Sandwich	1	7	S1		
Inappropriate/irrelevant teaching method	1	7			

Note. [a]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the calculation. [b]22 returns out of 23. However, since some students gave more than one preferred teaching sequences (e.g., S1), but some did not give any, the total number of responses may not be 22. [c]23 returns out of 23. See also b. [d]This is the cycle teacher talk/pupil activity/teacher talk/pupil activity. [e]23 returns out of 23. See also b. [f]The sequence for concept formation: experience-language-picture-symbol in which pupils learn to communicate concepts by ordinary and mathematical language. [g]15 returns out of 23. See also b.

In the second and third sessions, I introduced the "sandwich" and "ELPS" approaches, which were novel to the class of 2SC-97 students (Appendix 4C, Monday, 9/3/1998, page 340). These two approaches were similar to the "discovery" method and involved a considerable number of pupil activities. The "sandwich" approach emphasises pupils' working on assigned tasks most of the time (discussion is allowed) during the lesson, with the teacher intervening where necessary. The "ELPS" sequence also focuses on pupils' learning through recognising their prior experience (E) and using ordinary language (L), mathematics language and symbols (S), and pictures (P), where necessary, for communication. However, only a few student teachers suggested the use of these two sequences in their journals. The rate at which the word "sandwich" appeared in their journals on 2 March 1998 was only 17% and even fell to 1% on 16 March 1998. The use of "ELPS" was suggested by many more student teachers – 48% of the total of 23 student teachers attending the class session on 9 March 1998. This, together with another 13% of student teachers suggesting the use of the "discovery" method on the same date – totalled 61% of Class-97 members favouring the use of learner-focused approaches in teaching mathematics concepts. I interpreted this as a sign of student teachers' realisation that a more learner-focused approach would be more appropriate for concept teaching.

Students in the Case-97 also advocated a few teaching methods in their journals. The methods of S1, S2 and S3 displayed a teaching orientation that oscillated along the teaching continuum; a more teacher-centred approach was used most of the time, but the more pupil-centred learning was also mentioned at times. Since the problems I presented to them in different class sessions were different, these students may therefore have considered it appropriate to use different approaches to tackle different teaching problems, thereby exhibiting a variety of teaching methods. Explanations for their choice of methods can be found later in this chapter (pages 146-156, subsection: "Case Members' Beliefs About Teaching Mathematics, Phase I, 1997-98").

Table 4.4 also shows that Class-97 members did not posses a repertoire of teaching methods – only "exposition" and "discovery" appeared frequently as teaching approaches. Furthermore, there were some students who wrote inappropriate or irrelevant teaching sequences in their journals (9% in session 2, 35% in session 3, 7% in session 5, but none in session 4). Reasons were unknown (and no follow-up interviews were conducted to determine these reasons because of the time constraint). Probably, these student teachers did not have sufficient time to elaborate their teaching ideas, or they found it difficult to express their views. More guidance was provided in Phase II to assist student articulation in their journals (Appendix 4C, Mondays 16/3/1998 and 1/6/1998, pages 341 and 347; see also a later section "Recommendations for Phase II Implementation" in this chapter, pages 179-180).

Overall, the 2SC-97 students positioned themselves at various points along the teaching orientation continuum at different times. The pre-module BTM survey revealed quantitatively a more socio-constructivist orientation (page 118), but at the same time, the qualitative pre-module GTS questionnaire reflected a less learner-based teaching sequence (pages 127-128). In the second meeting, the 2SC-97 student teachers produced the same two orientations of pupil-centredness and teacher-centredness to teaching again – as seen from the analysis of their written journals about the teaching of specific topics in junior secondary mathematics (Table 4.4, page 130). Students' teaching orientation then swung from the more content-focused approach (2 March 1998) to the opposite end of the teaching continuum – the learner-focused pole – on 9 March 1998, and then back to the more expository end again on 16 March 1998.

Results from the GTS Questionnaire (Post-module), 1997-98

At the end of the last session (i.e., session 11 on 22 June 1998), the GTS questionnaire (which can be found in Appendix 3E, page 324) was administered again to the 2SC-97 Class. There were only 14 returns (see Table 4.5) providing the post-module data.

Table 4.5
The General Teaching Sequence (GTS) (Post-module) Stated by Student Teachers After the Module Ended in Session 11 (22 June 1998), Phase I, 1997-98 (N = 14)

Response[a]	Stated teaching sequence	n	%	Response by Case-97[b]		
(1)	Introduction-exercise-conclusion	13	93	S1	S2	S3
(2)	Discovery method	1	7		S2	

Note. [a]14 returns out of 23. However, since some students gave more than one preferred teaching sequences (e.g., S2), but some did not give any, the total number of responses was still 14. [b]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the calculation.

Surprisingly, the majority of the students put down the "introduction-exercise-conclusion" sequence again, indicating a content-focused and performance-based teaching orientation. All the three students of the Case-97 also put down this sequence, with S2 alone also expressing the use of the pupil-centred "discovery" approach.

Since similar kinds of data were obtained from the GTS questionnaire (pre- and post-module) and from the JWW, an amalgamation of these results presented a better picture of my student teachers' overall beliefs during this phase of teaching. Thus the results in Tables 4.3-4.5 (pages 127, 130 and 132) were consolidated with the GTS data to obtain Table 4.6. To consolidate the data for better analysis, the term "content-focused orientation" was equated with the sequences "introduction-exercise-conclusion" or "exposition" which appeared in the same Tables 4.3-4.5; whereas, the terms "discovery", "sandwich", and "ELPS" were taken as an indication of the more learner-interactive teaching disposition, i.e. "learner-focused orientation". Thus, in Table 4.6, student teachers' responses were grouped under the two orientations of (1) "content-focused" and (2) "learner-focused". Corresponding percentages of responses in all the sessions, 1-5 and 11, were summed and tabled against the relevant orientations. For instance, in session 3 of Table 4.4 (page 130), percentages related to "discovery" (4%) and "sandwich" (17%) were added to give 21%, which was then entered under session 3 against "learner-focused" in Table 4.6.

Apparently, there was no fixed teaching orientation: for a particular session (and hence perhaps for the teaching of a particular topic), Class-97 members would take a particular teaching stance. And yet Class-97 members seemed to hold the more popular performance-focused disposition towards mathematics teaching – four times out of six (sessions) the percentages of responses to the expository approach exceeded 60%. When the pre-module (session 1) and post-module (session 11) results of the GTS questionnaire were compared, the content-focused orientation was especially prevalent, and the response frequency increased from 80% to more than 90%. There was, seemingly, an entrenched belief about mathematics teaching as an exposition or knowledge transmission held by the whole class of students.

Table 4.6
The Teaching Orientation of the 2SC-97 Students Inferred from the General Teaching Sequence (GTS) Questionnaire and Journals (JWW), Phase I (1997-98)

	Percentage response					
	Session					
Teaching orientation	1	2	3	4	5	11
Content-focused	80	23	65	26	87	93
Learner-focused	27	23	21	61	20	7

Note.
Percentages were obtained from Tables 4.3, 4.4 and 4.5. As mentioned in the tables, since some students gave more than one preferred teaching sequences, but some did not give any, the total percentage response may not be 100%.
Percentage responses to the two items "introduction-exercise-conclusion" and "exposition" were added and entered against the "content-focused" teaching orientation in this table.
Similarly, percentage responses to the items "discovery", "sandwich" and "ELPS" were added and entered against the "learner-focused" orientation.

The next subsection will describe the post-module BTM survey results which could probably give more information about the class of student teachers' teaching orientation.

Results from the BTM Questionnaire (Post-module), 1997-98

In the last class session of the methodology module on 22 June 1998, the BTM questionnaire was administered again, with the data being analysed in the same way as for the pre-module survey (pages 116-119). (Appendix 4E, pages 359-360, records the means and standard deviations of items scored by the 2SC-97 Class of students and by the Case-97 students). In this subsection, the overall post-module responses to the BTM questionnaire, and the categorised responses will be reported and discussed, together with a comparison with the pre-module findings.

2SC-97 Overall Teaching Orientation (Post-module)

Table 4.7 compares the pre-module and post-module overall means of the BTM questionnaire scored by members of the Class-97 and the Case-97.

Table 4.7
A Comparison between the Pre-module and Post-module Overall Means of the Beliefs About Teaching Mathematics (BTM) Survey, Phase I, 1997-98 (N = 15)

	Class-97[a]	Case-97[b]		
		S1	S2	S3
Pre-module				
Mean	3.6[c]	3.7[c]	3.7	3.5
SD	1.0	1.2	1.0	0.9
Post-module				
Mean	3.4[d]	3.3[e]	3.7	3.1
SD	1.1	1.1	1.2	1.3

Note.
Responses were made on a 5-point scale (5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, 1 = strongly disagree).
[a]15 returns out of 23. [b]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the calculation. [c]S1 gave no response to item 30. [d]Two student teachers gave no response, one to item 13, the other to item 25. [e]S1 gave no response to item 25.

The post-module overall means of Class-97 members, S1 and S3 were between 3 and 3.5, implying that the whole class, including the two students S1 and S3, still held a content-understanding teaching orientation as before. Although they emphasised conceptual understanding of mathematics, by and large, they still considered that teaching should focus more on mathematics content. It could also mean that they focused more on the performance of their pupils rather than on the provision of opportunities for social interactions.

More surprisingly, at the end of the methodology module and their teaching practice, the overall mean scored by Class-97 members for all the 33 items of the BTM was slightly lower when compared with that obtained in the pre-module survey. This could be interpreted as a slight shift towards the more teacher-centred teaching orientation. As for the Case-97 students, the trend for S1 and S3 was similar to the 2SC-97 Class on the whole, as just seen; S2 alone maintained the same overall mean of 3.7 as at the beginning of the semester. His more learner-focused teaching orientation appeared unaltered during this period.

Although there is a drop in the overall mean of Class-97 members and in the two students S1 and S3 of the Case-97, one should not conclude that the student teachers had become more teacher-centred in their instruction approaches. As can be seen in Table 4.7 (page 135), the standard deviations for Class-97 members and for Case-97 members were all greater than one and, except for S1, the standard deviations had increased when compared with the pre-module results. For the whole class, it meant that the variation of both scores among different students and for each item was slightly larger. As for the Case-97 trainees, it implied that each student did possess different (and possibly contradictory) views about mathematics teaching. (See interpretation by Van Zoest et al., 1994, pp. 42, 44, 47)

In brief, variations in the values of the standard deviations obtained in all the calculations could be interpreted as indications of variation in beliefs among all the student teachers. Further in-depth analysis of the data in the next subsection allowed me to interpret the BTM findings more accurately.

2SC-97 Different Teaching Beliefs (Post-module)

Similar to the analysis of the pre-module survey, the data obtained from the BTM survey were also analysed by grouping the items into nine categories according to the interview questions in the INT. (See pages 118-119: "2SC-97 Different Teaching Beliefs (Pre-module)" for the nine categories; the interview schedule can be found in Appendix 3D, page 323). In the following, the findings from the scores and the calculated means for the grouped items (Appendix 4F, pages 361-363) are discussed and compared to those in the pre-module results (Appendix 4B, pages 331-333).

(1) Role of a Mathematics Teacher

Class-97 and Case-97 members agreed (and S2 agreed strongly) that it was the key responsibility of the teacher to encourage his or her pupils to explore their own mathematical ideas (Item 1). This view was also in agreement with what had been found in the pre-module results (see Category 1, page 119).

Regarding the creation of a non-threatening learning environment to facilitate exploration and learning of mathematics (item 6), Class-97 members, in a manner similar to their responses in the pre-module BTM questionnaire, also supported the view that an atmosphere should be fostered in which pupils would be free and safe to learn mathematics. The Case-97 students, however, responded differently from their pre-module consensual belief that an environment void of fear should be established for learning (see Category 1, page 119). S2 still concurred on this statement; yet, S3 did not agree and S1 was undecided. Reasons for the change in beliefs in S1 and S3 need to be investigated (see pages 146-156: "Case Members' Beliefs About Teaching Mathematics, Phase I, 1997-98" in a later part of this chapter).

(2) Questioning

Before the methodology module began and after it ended, both Class-97 and Case-97 members agreed that persistent questioning had a significant effect on their pupils' learning mathematics (see Category 2, page 119, for pre-module results). Sustained questioning might develop a cognitive conflict that might lead to adaptation wherein individuals negotiate meanings by continually modifying their interpretations.

(3) Mathematics Content

All belief items under this category were constructed in the content-focused sense and scores recorded in Appendix 4F, pages 361-363, had been reversed.

In the pre-module scores, as discussed earlier (Category 3, page 120), the 2SC-97 students could not decide whether there was a fixed amount of mathematics content to be covered (item 26, with scores reversed) and whether it was necessary to cover all of them in the textbook sequence (item 18, with scores reversed). At the conclusion of the methodology module, the 2SC-97 students were still unsure whether there was a fixed amount of mathematics content to be covered at each grade level (item 26, with scores reversed), but they believed that it was unnecessary to cover all the topics in the textbook sequence (item 18, with scores reversed). They seemed to change their mind, and concluded that they did not need to follow the textbook sequence.

However, the 2SC-97 students queried the kind of teaching sequence to follow (item 32, with scores reversed). At the beginning of the methodology module, the 2SC-97 students agreed that it was important to present the materials in a correct sequence; after the methodology module, they could not decide if their original decision was proper. Perhaps students understood that it was difficult to consider and judge the order of presentation of mathematics content for different pupils with different prior mathematical experiences and knowledge.

Furthermore, from the standard deviations (1.5, 0.5, 0.9) shown in the table (Category 3 in Appendix 4F, page 361), it looked as if there was a variation in student teachers' opinions about the amount of content to be presented to the pupils and the sequence of its presentation. Different student teachers appeared to hold different teaching beliefs.

The Case-97 students further exemplified the findings in their post-module responses (Category 3 in Appendix 4F, page 361). For instance, both S1 and S2 agreed that pupils should learn a specified amount of mathematics knowledge (item 26, with scores reversed), but S3 was undecided. While both S1 and S2 were doubtful as to the importance of presenting the relevant mathematics in a correct order (item 32, with scores reversed), S3 objected to this idea. Moreover, suspecting the importance of a correct sequence in teaching mathematics (item 18, with scores reversed), S1 did not agree to follow the textbook sequence; nevertheless, S2 strongly supported such an idea. S3, disagreeing with the importance of the employment of a correct teaching sequence (item 32, with scores reversed), further denounced the textbook sequence, describing it as a poor means of covering all the required mathematics content (item 18, with scores reversed).

Overall, there presumably were changes in Case-97 members' beliefs when pre- and post-module results were compared (see page 120 for a discussion of the pre-module responses regarding "mathematics content"). For instance, in their pre-module response to item 32 (with scores reversed), Case-97 members all agreed (with S2 strongly agreed) that they should follow a correct sequence in teaching mathematics, but at the end of the methodology module, Case-97 members doubted the importance of a correct sequence (with S3 disagreed) in presenting mathematics content. Indeed, throughout the methodology period, Case-97 members seemed to disagree with the importance of the textbook sequence in teaching mathematics (item 18, with scores reversed), although they insisted that there was an established amount of mathematics content to be presented to their pupils at each grade level (item 26, with scores reversed).

(4) Problem Solving

At the end of the methodology module, the 2SC-97 students agreed that a vital task for them was to motivate their pupils to solve their own mathematical problems (item 5) and to confront them with difficult problems in order to facilitate learning (item 29). These findings were also in agreement with the pre-module results (pages 121-122), thus implying that there were no belief changes in this respect.

However, the Class-97 students were undecided whether they had to provide any solutions to the mathematical problems (item 10, with scores reversed) and whether these solutions should be concisely and clearly presented (item 23, with scores reversed). These results contradicted what had been inferred from the student teachers' pre-module responses (pages 121-122) – they should not provide their pupils with solutions to mathematical problems, irrespective of the clarity and conciseness of the solutions. Thus, at the end of the methodology module, the 2SC-97 students were doubtful of the benefit of supplying solutions to their pupils to facilitate learning.

The opinions of the Case-97 trainees, as before, were different. S1 was in unanimity with the class of 2SC-97 students. She supported the proposal that she had to motivate her pupils and let them struggle with problems (items 5 and 29), but she was not sure if she had to provide lucid solutions to help pupil learning (items 10 and 23, all with scores reversed). Her ideas about motivating pupils and challenging them were also in line with her pre-module beliefs (pages 121-122). However, S1 became less definite in considering the provision of solutions to her pupils at the end of the methodology module when compared to her previous beliefs.

S3's response to item 5 indicated that he should stimulate his pupils in solving problems on their own and that he did not agree with letting his pupils develop any tensions during the problem-solving process (item 29). He was not sure if he should provide any solutions to these problems (item 10, with scores reversed), although he felt strongly that clear and concise solutions to problems were unnecessary (item 23, with scores reversed). These post-module results showed that S3 became more determined to avoid providing challenges and methods of solution in problem solving (compare the pre-module results on pages 121-122).

S2 was probably the most traditional in teaching mathematics among the students in the Case-97 study group in this respect (contrary to the fact that his single overall mean of 3.7 in both the pre- and post-module BTM response, page 135, was the highest, representing a strong pupil-centred orientation). He was in agreement with creating opportunities to perturb his pupils (item 29), but he was not sure if it was necessary for him to motivate his class (item 5). He also showed his support for presenting clear and simple solutions to assist mathematics learning (items 10 and 23, all with scores reversed).

When comparing the pre- and post-module results, S2 seemingly changed to the more teacher-oriented perspective at the end of the module (compare the "problem solving" category in Appendix 4B, page 331 and Appendix 4F, page 361). His response to item 29 was unchanged; whereas his scores for items 5, 10 and 23 changed from 4, 3, 4 to 3, 2, 2 respectively. From agreeing to motivate his pupils in problem solving (item 5) at the start of the methodology module, he became irresolute at the end of the module; from uncertainty about providing solution methods (item 10, with scores reversed) and disagreement with supplying concise methods of solution (item 23, with scores reversed), S2 became supportive of the provision of clear and concise solutions in problem solving.

(5) Group Interaction

Similar to their beliefs at the beginning of the methodology module (see Category 5, page 121), members of the Class-97 still appeared to possess constructivist beliefs regarding the effectiveness of learning mathematics in small groups through social interaction at the end of the module. The student teachers believed that mathèmatics was not best learnt individually (item 12, with scores reversed), but by working together (item 27) and by discussion among the pupils themselves (item 31). Hence, Class-97 members preferred to arrange interesting problems for small-group investigation (item 19) and provide opportunities for self-reflection and evaluation of pupils' own learning (item 25).

Learning in groups had not been fully supported by members of the Case-97 at the pre-module stage (page 121). For instance, S3 did not agree with the effectiveness of pupils working together and discussing among themselves. However, at the end of the module, there were apparent positive belief changes. Though S3 still queried the effect of discussion in assisting learning (item 31), Case-97 members generally supported learning in small groups as an effective means of teaching mathematics.

(6) Teacher Exposition

All items under this category were in the content-focused sense; scores for these items were reversed.

Members of the Class-97 seemed to become more determined that teaching required teacher demonstration, explanation and description of concepts and skills (items 11 and 30, all with scores reversed) and that follow-up instructions could amend their pupils' learning difficulties and misconceptions (item 21, with scores reversed). However, it was presumably true that they still felt doubtful (as they did initially; see page 122) whether telling their pupils the answers could be an efficient way of facilitating learning (item 22). (See Category 6, pages 122-123, for pre-module results.)

Case-97 members exhibited some changes in their original beliefs about teaching mathematics (compare the "teacher exposition" category in Appendix 4B, page 332 and Appendix 4F, page 362). Two of the three students in the Case-97 (S2 and S3 at the beginning of the module; but S1 and S2 at the end) still agreed not to provide answers to their pupils, because telling the answers might not be the most efficient way of learning (item 22, with scores reversed); otherwise, it looked as if Case-97 members' beliefs converged from different initial views to some commonly agreed teaching ideas. For instance, in the pre-module findings, S1, S2 and S3 did not all agree that pupils listening to the teacher explaining was the most effective way to learn mathematics (item 11, with scores reversed). At the end of the module, nevertheless, all three student teachers agreed (and two of them, namely S1 and S3, agreed strongly) that this method was the best. Likewise, they also changed their views about exposition (items 30, with scores reversed) from "not supported" (for S3 alone) and "not decided" (for both S1 and S2), to "supporting" this teaching approach (by both S1 and S3 with S2 undecided). Full approval for the use of follow-up instructions in correcting pupils' errors was also given by the Case-97 students (item 21, with scores reversed).

(7) Personal Construction

The idea that different pupils possess different prior knowledge of mathematics because knowledge construction is personal was supported by the whole class of

2SC-97 students in the pre-module findings (Category 7, pages 123-124). However, in the post-module results in this respect, mean scores of Class-97 members decreased slightly and particularly for items 3, 7 and 8 (where scores for item 7 were reversed). Class-97 members, although agreed that the solution process was equally important as obtaining the answer (item 3), no longer showed such strong approval as before. Rather than feeling fascinated at different pupil perspectives, Class-97 members appeared to doubt if they felt comfortable with pupils' novel mathematical ideas (items 7 and 8, with scores reversed in item 7).

Case-97 members again endorsed different ideas in the post-module responses (see pre-module results in Category 7, pages 123-124). S2 scored very high in almost all the items in this category, thus exhibiting his outwardly learner-centred teaching orientation. S1's scores ranged from 1 to 5, with more low scores than high ones – thus indicating her seemingly more teacher-focused orientation, and possibly indicating a reluctance to acknowledge multiple mathematical perspectives constructed by her pupils. Agreement scores by S3 were the lowest, showing that S3 was rather content-focused and emphasised performance: He would not consider that listening to his pupils' mathematical ideas was important in teaching. When pre- and post-module results were compared (Category 7 in Appendices 4B and 4F, pages 332 and 362 respectively), both S1 and S3 had distanced themselves from the learner-interaction extreme towards the more content-focused end of the teaching continuum at the end of the module.

(8) Teaching and Learning Mathematics

Regarding the nature and learning of mathematics, members of both Class-97 and Case-97 held similar views in general and there were no appreciable changes seen in the beliefs. (Compare the category "teaching and learning mathematics" in Appendices 4B, pages 332-333, and 4F, pages 362-363.)

Both Class-97 and Case-97 members were not clear whether learning mathematics required a considerable amount of effort in memorising facts and skills (item 9, with scores reversed); whether mathematical problems could be solved without using any rules (item 24), and if mathematics was made up of disconnected topics or not (item 13, with scores reversed). However, both agreed that as mathematics teachers, it was important to understand the relevant mathematics structures (item 28) and to enjoy learning and doing mathematics (item 16).

(9) Teacher Change

At the beginning, Class-97 members were positive, as a whole, that they could develop an inquiring attitude when teaching experiences had been accumulated, but at the end of the methodology module it appeared that they could not decide if any attitude could be developed (item 20). As for the Case-97 study group, S1 remained indecisive, S2 remained positive, but S3 became negative. (See the category "teacher change" in Appendix 4B, page 333, and Appendix 4F, page 363.) As these first-year student teachers had only four weeks of teaching experience in secondary schools organised within the period of the methodology module, it is understandable that they might not have experienced much professional growth.

Summary (Post-module BTM Results, 1997-98)

In this first phase of implementing the constructivist model of teaching a methodology class, results showed that Class-97 members, as well as the three outstanding student teachers, displayed individual beliefs about teaching mathematics. These teaching beliefs were generally different, with variations in the focus. (See their overall teaching orientation, pages 134-136; their different teaching beliefs, pages 136-144.)

They had strong, though not necessarily entrenched, beliefs that indicated support for a learner-centred teaching orientation which emphasised learner interaction at the beginning of the methodology module. At the end of the module, student teachers tended to adopt a more content-focused perspective emphasising conceptual understanding (pages 134-136). They seemed to be in greater congruence with the usual espoused beliefs in mathematics teaching in Hong Kong (Chapter One, pages 2, 8-11).

Specific teaching beliefs stipulated in the BTM questionnaire were grouped into nine categories and were discussed (pages 136-144). The comparison between pre- and post-module beliefs is drawn as a summary in Appendix 4G (pages 364-365) – in which agreement scores for individual belief items (all converted to learner-focused statements) by Class-97 and Case-97 members in both the pre- and post-module BTM questionnaires are recorded. The agreement scores are presented in the form of "ticks", and the degree of agreement increases when the number of "ticks" increases. An item without any "tick" represents either "undecided" or "disagree".

From Appendix 4G (pages 364-365) and the discussion of pre- and post-module BTM results in an earlier subsection "2SC-97 Different Teaching Beliefs (Post-module)" (pages 136-144) in this chapter, the 2SC-97 students appeared to hold unchangeable beliefs in their role as teachers who encouraged pupils to learn mathematics (Category 1, page 364; see also pages 136-137). They acknowledged the use of persistent questioning in altering their pupils' mathematics knowledge (Category 2, page 364; see also page 137). They also believed in the effectiveness of group interaction (Category 5, page 364; see also page 141), but at the same time became more inclined to the traditional expository approach (Category 6, page 364; see also pages 141-142). Results in Appendix 4G also indicated that they lacked a good understanding of the nature of mathematics, but that they understood the need to build up and consolidate their mathematics foundation and to develop their interest in learning mathematics (Category 3, page 364; see also pages 137-139; Category 8, page 365; see also pages 143-144). Furthermore, student teachers were unable to decide if they could develop an attitude of inquiry when more experience was accumulated (Category 9, page 365).

There were two categories of items that showed signs of changes: (1) changes in beliefs about personal knowledge construction (Category 7, page 365; see also pages 142-143), and (2) changes in the ideas about problem solving (Category 4, page 364; see also pages 139-141). The 2SC-97 students changed their original views, although only slightly, to the belief that it was always necessary to start teaching from their pupils' prior experience. They also became doubtful about he idea that mathematics teachers should not provide pupils with clear and concise solution methods of how to solve problems.

Case Members' Beliefs About Teaching Mathematics, Phase I, 1997-98

S1

As seen in Table 4.7 (page 135), the overall mean scored by S1 for the BTM questionnaire at the pre-module stage was 3.7 (SD = 1.2), implying that S1 displayed a socio-constructivist teaching orientation. Her overall mean was, in fact, slightly above the Class-97 mean of 3.6. Her post-module BTM mean, however, was only 3.3 (SD = 1.1), which was lower than her pre-module mean and slightly lower than the Class-97 overall post-module mean, which was 3.4. These quantitative data showed that S1's beliefs appeared to have shifted slightly away from a more socio-constructivist stance towards a less learner-focused orientation.

In her response to the initial GTS questionnaire in the first class session, S1 wrote: "teacher-introduction, pupil exercise, teacher summary" as the teaching sequence she would like to use (Appendix 4H1, page 366). This response to the open-ended question, contradicting the finding from the pre-module BTM, revealed her preference for using an expository approach to teaching mathematics, emphasising teacher-talk and pupils' mastery of mathematics through exercises. S1's response to the GTS questionnaire at the end of the module differed. The teaching sequence she expressed was: "revision-motivation-discussion-classwork-summary" (Appendix 4H1, page 366). While this still indicated that S1 held a content-focused orientation towards mathematics teaching, she presented a more elaborate teaching sequence than at the beginning of the module, with an awareness of a need to motivate pupils and providing opportunities for discussion. Her highlighting of the use of classwork in her teaching showed that she emphasised mastery of rules and procedures and possibly signalled an entrenched belief that mathematics learning required a lot of drills and practices.

In her journals (Appendix 4H2, pages 367-371), S1 showed signs of a variety of teaching orientations. Her record of how she planned her mathematics lessons reflected that she had several methods of teaching in mind – some being more learner-focused, others more content-focused. Which particular method S1 preferred depended on the kind of topics for the lesson and the characteristics of pupils in a specific class:

> We can use two methods to teach a concept – expository or discovery. It is much better to use the discovery method because pupils can have a better impression of the concept. But if pupils' ability is low, we can also use the expository method because pupils do not have the ability to discover new concepts. In addition, we can also use the discovery method for low ability pupils if we can provide guidance to them. (Appendix 4H2, Monday, 23/2/1998, page 367)

In another journal (Appendix 4H2, 9/3/1998), she indicated that her approach in teaching a concept in the lesson was restricted to the use of the lecture method, yet she then remarked that the more pupil-centred method, the "ELPS" sequence, was worth trying. As for the teaching of skills, S1's journals also showed that she favoured the more learner-focused approaches – for instance, the discovery strategy and the "sandwich" approach (Appendix 4H2, 16/3/1998, page 370).

These highlights from S1's journals give evidence that S1 was not using the expository approach solely; rather, she applied different approaches – expository and discovery – in different contexts. She also reflected on her teaching after lessons and was willing to try other methods which have been introduced by me. Her statement in response to the GTS questionnaire was probably only a simplified exposition of her thinking.

During the teaching practice however, S1 was observed to demonstrate a mainly content-performance orientation in one of her lessons. Though she planned a sufficient number of pupil activities for the 40-minute lesson, her focus was on the mastery of skills (Appendix 4C, Wednesday, 13/5/1998, 341). At the end of the lesson, S1 evaluated her own teaching as: "It was confusion" (Appendix 4H3, page 373). I can see from this assertion that S1 intended to be more learner-focused but, probably due to her inexperience, was ineffective in implementing what she had planned, resulting in a teacher-centred lesson.

The interview with S1 (with INT as the instrument), after the methodology module was over, aimed to clarify her beliefs about teaching mathematics and to provide me with further information about S1's inclination to mathematics teaching. The transcript is attached to Appendix 4H4 (pages 375-376), and my understanding and interpretation of the conversation or stated beliefs can be found in Appendix 4C (page 352).

One important finding in the interview was that S1 seemed to underscore the teacher as facilitator and the pupil as constructor of mathematics knowledge:

> A mathematics teacher has to inspire pupils so that they can develop critical thinking and an inquisitive attitude. (Appendix 4H4, page 375: Answer to question 1)

and

> I think it is important that pupils can explain their own solution....this will imply that pupils do obtain the solution by their hard work. (Appendix 4H4, page 376: Answer to question 7)

In the interview, S1 also maintained that when her pupils could not solve a problem, she usually just remained silent without trying to encourage and motivate her pupils to resolve the problem on their own (Appendix 4H4, page 375: Answer to question 5). This assertion possibly echoed her quantitative responses to the BTM questionnaires (1) she supported motivating her pupils in problem solving, (2) she would let pupils struggle with problems, (3) she could not decide whether she had to provide any solutions to pupils or not (see discussion on the category "problem solving" earlier in this chapter, pages 139-141).

The interview data also showed that S1 was flexible with her choice of teaching activities and that she considered that it was not important to cover all the topics in the mathematics curriculum (see S1's answer to question 3, Appendix 4H4, page 375).

It is worthy to note also that S1 sometimes displayed a transmission teaching behaviour – in responding to question 6 in the interview, S1 admitted that she provided extensive demonstrations in her teaching (Appendix 4H4, page 375: Answer to question 6). Other findings in the interview could offer some explanation to S1's adoption of this mode of instruction during the teaching practice. S1 indicated that after teaching practice, she found that teaching mathematics was much more difficult than expected, and that pupils were not motivated at all: "New ways of teaching cannot have the perceived effect" (Appendix 4H4, page 376: Answer to question 8). Her skills in classroom management bothered her and somehow deterred her from using these methods effectively (Appendix 4H4, page 376: Answer to question 9).

Overall, S1 gave me the impression that she would like to be a facilitator of pupils' learning in general and that she would like to employ various teacher activities which she had developed from participating in my methodology class.

She also aimed at involving pupils in knowledge construction, though not always successfully.

S2

From Table 4.7 (page 135), S2's overall mean scores for the BTM questionnaire were the same (3.7, with SD ranging from 1.0 to 1.2) for both the pre- and post-module surveys. This implied that S2's orientation to teaching was that of the socio-constructivist stance throughout the methodology module.

As for his responses to the GTS questionnaire, S2 expressed a preference for the discovery method of teaching at the beginning of the module, but at the end he suggested both the discovery method and an expository approach. He also seemed to have given greater emphasis to the mastery of procedures in solving mathematics problems. (See Appendix 4I1, page 377, for his responses to the GTS questionnaire.)

The journals of S2 also confirmed that, within the time-frame of my methodology module, he had considered the expository approach also appropriate for mathematics teaching in addition to the discovery method. In one of his journals, S2 posited the use of an expository approach which involved pupils communicating and using names of mathematics concepts which appeared repeatedly in numerous examples supplied by both the teacher and the pupils (Appendix 4I2, 23/2/1998, 9/3/1998, pages 378 and 380 respectively). However, he asserted that he was not advocating exposition – which to him was a boring method – in lieu of the discovery approach which he considered difficult to apply and was less commonly used. He wrote:

> I myself would prefer the use of the discovery method, but I know this method is difficult to apply and not so common. (Appendix 4I2, Monday, 9/3/1998, page 380)

> Teaching a concept is probably a routine task, but I think I have to overcome this feeling of boredom because the most important thing is to let pupils understand clearly the important attributes of a concept. (Appendix 4I2, Monday, 9/3/1998, page 377)

The approach S2 adopted in the lesson which I observed was quite surprising. (The lesson I observed and the follow-up discussion are recorded in Appendix 4I3, pages 383-386.) In the lesson, S2 demonstrated how to solve some mathematics problems on the chalkboard and asked his pupils to imitate exactly what he did, not accepting any other possible methods given by his pupils. He also did not provide opportunities for pupils to work out the problems on their own, although quite a number of them urged the teacher to let them try out the solutions. I found that this behaviour of S2 contradicted his response in the pre-module BTM survey in which he agreed that "a vital task for the teacher is motivating children to resolve their own mathematical problems" (Item 5, Appendix 4A, page 329). (Later, I discovered that his response to this item in the post-module BTM questionnaire was "undecided"; see Appendix 4E, page 359.) In the post-lesson discussion with him, S2 seemed to have negatively interpreted pupils' urges to solve problems on their own:

> Pupils seemed not satisfied with nothing to do in class, and that is why in the lesson, they urged me to let them try to solve the problems rather than my demonstration. (Appendix 4I3, page 385)

He also seemed to think that asking pupils to follow his demonstrations could reduce disruptive behaviour in class, as he said: "The faster boys were the troublemakers" (Appendix 4I3, page 384). He also remarked:

> Pupils like to be told, especially the boys. I think they enjoyed the joy of solving difficult problems rather than the joy of discovering a mathematics result. (Appendix 4I3, page 384)

The discussion with S2 also revealed why he rejected the discovery method completely:

> I did try to use the discovery approach, but the effect was not too good. Pupils were playing and there was confusion....Time is spent and nothing could be achieved. (Appendix 4I3, page 384)
>
> I think discovery could be used in primary schools, but not in secondary. Exposition is much better. (Appendix 4I3, page 384)

While the change of S2 towards the use of a more teacher-centred expository approach seemed to be a result of his direct experience in teaching, the influence of other teachers in this teaching practice school appeared also significant:

> The regular teachers told me that this class is the worst and so they could not do any difficult problems like proofs. (Appendix 4I3, page 384)

Later, the interview with S2 using the INT further confirmed that S2 positioned his teaching orientation more towards the content-focused end of the teaching continuum rather than the learner-focused end (Appendix 4C, Monday, 29/6/1998, page 353):

> I will make use of the recess or after school hours in catching up with the necessary progress. (Appendix 4I4, page 387: Answer to question 3)
>
> I have done a lot of demonstrations; and sometimes, overdoing it. (Appendix 4I4, page 387: Answer to question 6)

During the interview, S2 also admitted that he had changed his views about mathematics teaching after the teaching practice. He had abandoned his original belief about teaching mathematics by the discovery approach, possibly because of the behaviour and attitude of his pupils:

> Teaching practice indeed changed my perception of teaching and learning. The discovery method which I always think useful in teaching could not be used. I also find stimulating interest in learning very important. (Appendix 4I4, page 387: Answer to question 9)

This quotation of S2 confirmed that he considered the discovery approach a "failure" after his teaching practice, though at the start of the methodology module he had expressed his preference for the discovery method in his response to the GTS questionnaire.

Overall, S2 moved towards the use of a more teacher-centred approach to teaching. When quantitative data in the BTM survey are compared, S2's teaching would be characterised by socio-interactive beliefs. However, from the way S2 described his teaching and how he performed during observation, he struck me as a transmitter of knowledge rather than a facilitator of pupils' learning. What he practised at the end of the module seemed to have contradicted the original stated learner-focused attitude expressed in many places, for instance, in his journals. His field experience in the secondary school seemed to have a significant effect on his teaching behaviour.

S3

In both the pre- and post-module responses to the BTM survey, the overall mean of S3 (respectively 3.5 and 3.1 in Table 4.7, page 135) was the lowest among the three students in Case-97 and compared to Class-97 members as a whole. S3 was just in the learner-focused range in the pre-module survey and moved towards the content-understanding range at the end of the methodology module.

In his response to the pre-module GTS questionnaire, S3 showed preference in using both the expository and discovery approaches, but his responses were restricted to the former in the post-module GTS questionnaire. (See S3's pre- and post-module responses in Appendix 4J1, page 388.) His journal records (Appendix 4J2, pages 390-392) also showed that S3 was inclined to use the expository approach most of the time.

The same practice could also be observed in his field experience when I observed his lesson on Monday 18/5/1998 (Appendix 4J3, page 394). S3 started with the discussion method at first, but then quickly switched to a direct instruction. S3 performed very satisfactorily in his explanation, giving examples and non-examples to illustrate the concepts, asking pupils to carry out some individual work in between his explanation. My observation showed that S3 seemed to lack the experience in handling class discussion and so avoided doing so, even though he wished to. The only activities he managed to satisfactorily implement involved asking pupils to work individually and answer his questions.

Contrary to the findings in the post-module BTM survey, the interview data at the end of the module showed that S3 displayed a socio-constructivist teaching orientation. In his answers to the ten questions in the INT which focused on beliefs about teaching mathematics (Appendix 4J4, pages 397-398), evidence of the learner-interactive focus abounded (see also Appendix 4C, page 354). For instance,

> The major role of a mathematics teacher can be: (i) stimulate pupils...(ii) develop pupils...(iii) assist pupils in clarifying and solving problems...(iv) create opportunities for pupils in critical thinking. (Appendix 4J4, page 397: Answer to question 1)

> In class, frequent use of questioning provides opportunities for pupils to reason among themselves and for interaction between pupils and the teacher, thus creating an appropriate learning environment. (Appendix 4J4, page 397: Answer to question 2)

However, in the interview, S3 explained that his use of the other less learner-focused methods demonstrated his flexibility in choosing learning activities for classroom teaching:

> I have also found that I did a lot of demonstrations by examples, of explanations, and of procedures. (Appendix 4J4, page 397: Answer to question 6)

> The use of different teaching methods increases the effectiveness of pupil learning (Appendix 4J4, page 398: Answer to question 8)

> We must be flexible in the choice of methods....In order to meet the needs of our pupils who surely have different capabilities, we must have different teaching methods. However, more activities for pupils should be planned so that they can participate actively in their learning. (Appendix 4J4, page 398: Answer to question 10)

My interpretation of the interview data was justified by S3's journal entries – for instance,

> If the concept is a concrete one, we can employ the discovery method. If the concept requires a definition, then we use the lecture mode. (Appendix 4J2, Monday, 9/3/1998, page 391)

S3's responses to the INT also indicated that he considered that the provision of encouragement and guidance to pupils was important:

> The steps are: (i) first comfort the pupils, acknowledge their effort spent, and encourage a joint effort in the new attempt at solution,..., (iii)...guide them to solve the problems, (iv) again acknowledge and praise pupils' hard work. (Appendix 4J4, page 397: Answer to question 4)

As seen in the foregoing discussion, data collected by different methods seemed to provide a contrasting picture of S3's teaching beliefs (e.g., differences between the BTM and the INT data). However, overall, it appeared that S3 believed that both teaching on the basis of pupils' prior experience and provision of relevant interesting activities could help pupils to build up their confidence and develop enthusiasm in learning (Appendix 4J4, pages 397-398: Answers to questions 1, 2 and 9; Appendix 4C, page 354). The teaching practice did not appear to change S3's original pupil-centred beliefs about mathematics teaching, although his lack of experience and skills probably led him to do so (Appendix 4J4, page 397: Answer to question 8). Within the period of the methodology module and the teaching practice, S3 had developed the belief that a variety of teaching methods should be used to cater for the different abilities of his pupils, and that teaching can be effective only when it was based on learners' prior experience including the provision of interesting activities. I considered that S3 possessed a socio-constructivist teaching orientation.

Summary (Case Members' Beliefs, 1997-98)

A detailed study of Case-97 members' data collected by various methods before, during and after the methodology module showed that it was difficult to conclude that these students held a socio-constructivist view of teaching – rather, in general, they held a learner-focused orientation. They recognised the value of involving pupils in activities – including requiring them to discover ways to solve mathematical problems – but were often restrained from organising these class activities because of their lack of experience and competence in managing the class under such circumstances. The classroom situation created by their pupils even made them query the feasibility of their original belief about using a more learner-focused teaching approach.

Overall Results (Teaching Beliefs, 1997-98)

This subsection summarises the evidence obtained from the various data collection methods with respect to Class-97 and Case-97 members' beliefs about teaching mathematics at the end of the methodology module.

Class-97 Outcomes

- The standard deviations in the scores of the BTM questionnaires (both pre- and post-module) indicated that collectively the 2SC-97 students possessed a variety of teaching beliefs (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- The BTM results portrayed a learner-focused orientation to teaching mathematics among the students at the start of the methodology module (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- The 2SC-97 students became slightly more teacher-oriented at the end of the methodology module, as reflected from the overall mean scores of the BTM surveys (pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)"). This was also reflected in the teaching sequences obtained from the GTS questionnaires (pre- and post-module) and the journals (pages 132-134 in an earlier subsection of this chapter: "Results from the GTS Questionnaire (Post-module), 1997-98").
- In the course of the module, student teachers' stated instruction sequences oscillated between the learner-focused end and the teacher-centred end of the teaching continuum (as seen in the GTS questionnaire and the journals, pages 132-134).
- From the categorised BTM results, Class-97 members held unchanged beliefs about the role of a mathematics teacher – as encourager of pupil

learning (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").

- There was no change in their acknowledgment of the use of persistent questioning in altering pupil knowledge about mathematics (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- There was no change in student teachers' belief in the benefits of group interactions in learning mathematics (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- The student teachers changed to adopt the expository approach in teaching (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)"). This was also verified in the stated teaching sequences in the journals and in the GTS questionnaires (see pages 132-134 in an earlier subsection of this chapter: "Results from the GTS Questionnaire (Post-module), 1997-98").
- Student teachers still maintained an indecisive attitude towards acknowledging their pupils' alternative mathematics knowledge, but seemingly remained open to allowing their pupils to justify their arguments (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- When teaching problem solving, they became unsure about whether they should provide clear and concise solutions to their pupils or not (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)")
- There were no changes in student teachers' understanding of the kind of mathematics content to be taught, the amount and the order of presentation – they could not decide at all (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)"; see also Category 3, pages 137-139).
- Generally, student teachers remained unable to understand the nature of learning mathematics: (1) Does learning mathematics require no

memorisation? (2) Is mathematics made up of related topics? (3) Can mathematics problems be solved without using rules? (See pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)"; see also Category 8, pages 143-144.) This inadequate understanding of mathematics was also echoed by critical friend C in her comments about student teachers' mathematics knowledge (see a later subsection of this chapter: "Phase I – Critical Friend C's Comments", page 171).

- Student teachers continued to believe that, as teachers, they had to understand mathematics and needed to enjoy learning it (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").
- Student teachers were still indecisive about whether they could develop an attitude of inquiry while they were accumulating teaching experiences (see pages 144-146 in an earlier subsection of this chapter: "Summary (Post-module BTM Results, 1997-98)").

Case-97 Outcomes

- The three outstanding students in the Case-97 displayed content-focused teaching orientation and were slightly more teacher-oriented than the whole class regarding their viewpoints about mathematics content (Category 3) and personal construction of knowledge (Category 7). This was reflected from their scores for the BTM questionnaires (pages 134-136; Category 3, pages 137-139; Category 7, pages 142-143), the general teaching sequences stated in the GTS questionnaire and in their journals (pages 127-134) and their teaching performance (see their lack of experience and competence in organising class activities in "Summary (Case Members' Beliefs, 1997-98)", page 156).
- Pupil motivation was a problem facing the Case-97 students in their school experience (see descriptions about individual student S1, S2 and S3, pages 149, 151 and 154). The school teacher affected S2's performance (see

description about S2, page 152). Lacking the relevant teacher experience was a problem for S3 (see description about S3, page 154).

The next section reports on the class learning environment created in my methodology classroom in the Phase I study.

PHASE I – THE CONSTRUCTIVIST LEARNING ENVIRONMENT

To investigate the extent to which I have set up a social constructivist learning environment in my methodology classroom in the Phase I implementation, I made use of different forms of data collected from the Constructivist Learning Environment (CLE) questionnaire, student teachers' journals (JWW), interviews (INT) and post-lesson discussions with the Case-97 students, and observation notes of my critical friend C. (The CLE questionnaire can be found in Appendix 3F, pages 325-327; the guidelines for JWW can be found in Appendix 3B, page 319; and the INT can be found in Appendix 3D, page 323. There were no specific guidelines for post-lesson discussions with the Case-97 study group and for observation notes by my critical friend C.)

Results from the CLE Survey (22 June 1998)

My Constructivist Learning Environment (CLE) Survey (found in Appendix 3F, pages 325-327) was designed to measure students' perceptions of the frequency of occurrence of five dimensions of a constructivist learning environment (see Chapter Three, page 96). It was administered to my class of student teachers in the last class session on 22 June 1998 (see Chapter Three, pages 98-99). There were 15 returns (including those by the Case-97 students) out of the 23 students present in the class that day. Frequency response data to a five-point Likert scale (1 for "almost never" and 5 for "almost always") were entered into a computer file, and the average frequency score for each of the five categories – by members of the Class-97 and of the Case-97 – was calculated and tabulated in Table 4.8.

Table 4.8
The Mean Frequency Scores for the Constructivist Learning Environment (CLE) Survey (22 June 1998), Phase I, 1997-98

CLE		Class-97[a]	Case-97[b] S1	Case-97[b] S2	Case-97[b] S3
LP					
	Mean	3.7	3.3	4.5	3.5
	SD	0.7	0.8	0.6	0.6
LM					
	Mean	3.4	3.5	3.8	3.7
	SD	0.9	0.5	0.8	0.5
LS					
	Mean	3.8	3.7	4.2	3.7
	SD	0.7	0.5	0.4	0.5
LL					
	Mean	3.0	3.0	4.2	3.0
	SD	0.8	0.0	0.4	0.0
LC					
	Mean	4.0	3.7	5.0	3.3
	SD	0.9	0.8	0.0	0.5

Note.
Responses were made on a 5-point scale (5 = almost always, 4 = often, 3 = sometimes, 2 = seldom, 1 = almost never).
There are five categories of learning:
- LP = learning about pupils' learning
- LM = learning about methodology
- LS = learning to speak out
- LL = learning to learn
- LC = learning to communicate.

[a]15 returns out of 23. [b]Case-97 consisted of three outstanding student teachers S1, S2 and S3 chosen from Class-97; their responses were also counted in the calculation.

Class-97 members' mean frequency scores for three of the five categories (except LM and LL) of learning about secondary pupils' learning (LP), learning about methodology (LM), learning to speak out (LS), learning to learn (LL), and learning to communicate (LC) were relatively high (about 4) – meaning that my students agreed that there were often opportunities to enhance their learning in the three dimensions (see Chapter Three, pages 96-98: Interpretation of frequency scores by P. C. Taylor et al., 1997). S2, in particular, gave very high scores to all the five categories.

The high scores for LC (4.0) and LS (3.8) by the Class-97 students implied that there were very often opportunities for student teachers to learn to communicate with one another and with me. Probably an interactive environment had been created. Both S1 and S2 seemed to support this finding, for they gave relatively higher scores for these two categories of learning (all greater than 3.5) than those scored by S3. While he considered that there were many opportunities for LS (a score of 3.7), S3 gave a lower score to LC (3.3), thus showing that there were fewer opportunities for student negotiation. Written descriptions in journals by the Case-97 students in this respect would be appropriate (S1 was absent on the day and did not submit any descriptions about my classroom environment), and further discussion on the responses by S1, S2 and S3 will be given later in this chapter (pages 168-170).

There were also opportunities for my students to learn about pupil's learning (LP) (Class-97 members' score of 3.7, S2's score of 4.5 and S3's score of 3.5 were quite high). However, the perception of S1 was different. The score of 3.3 by S1 could be interpreted as meaning that I had not provided sufficient chances for learning about their pupils' learning, or that the content I prepared had no direct relevance to their actual classroom teaching. Further discussion on this matter will be provided in the journals subsection later (pages 162-168).

There were seemingly not enough learning activities provided to engage the student teachers in learning about the teaching methodology (LM) as indicated by the Class-97 students' score of 3.4. A possible reason for the invariance of my students' teaching beliefs as discussed earlier (pages 157-159) could be my ineffective design of activities belonging to the two categories of LP and LM, or that the designed activities did not meet my students' expectations. Since learning about pupils' learning and teaching methodology were both considered by student teachers to be very important for their future career, it appeared that this aspect should be noted and improvement should be made in the next phase of my study (Appendix 4C, Monday, 22/6/1998, pages 350-351).

The comparatively low scores by almost all – the Class-97 students, S1 and S3 – for the category LL was inevitable. The predetermined syllabus and assessment structure of the methodology module leave very little flexibility in the content to be learnt and in the arrangement of the assessment activities; the amount of time available (about 30 contact and directed studies hours) to spend on the learning of the module content is also fixed. In other words, student teachers found that they were unable to control their own learning. Nevertheless, I believed that the allocation of assessment topics by lot to individual student teachers, and the conduct and adaptability of the various learning and reflective activities during the meetings could provide some flexibility in my students' learning. LL still managed an average score of 3 (the one exception was the exceptionally high rating by S2.)

Results from 2SC-97 Student Teachers' Journals (JWW)

The 2SC-97 students' journals were collected on 30 March 1998 (there were only ten returns including journal entries of S2 and S3; S1 was absent on this day). Student teachers' opinions recorded in these journals, together with the additional viewpoints found in S2 and S3's journals, dated 9 March 1998 (Appendices 4I2 and 4J2, pages 378-382 and 389-393 respectively), were examined. In analysing their journals, I classified their opinions about the activities of the methodology class into seven categories – namely (1) journal writing, (2) small-group discussion, (3) presentation of groups' ideas, (4) whole-class discussion, (5) lecturer intervention during group discussion, (6) lecturer input during class discussion and (7) others. Appendix 4K (pages 399-400) shows student teachers' major comments in each category, and the frequency and percentage of each. The following subsections summarise and discuss those results which had implications for the next phase of my study.

Journal Writing

Half of the respondents indicated that they liked journal writing (Category 1 in Appendix 4K, page 399). They claimed that writing journals helped them in reflecting on their teaching; an example is quoted from S3's journal:

> I...like writing journals. The journals can give opportunities for reflection on what we learnt. In the process of reflection, we have a formative evaluation about our learning outcome so that we can improve our weak points, and reflect retrospectively on what we learnt from other members of the class. (Appendix 4J2, Monday, 9/3/1998, page 391)

S2 seemingly had contradictory feelings about journal writing:

> I like it and I hate it. It helps to revise, and it also lets us to have a chance to feedback. But in some class meetings, I found it very difficult to write anything; I spent a lot of time to continue writing. Overall, I like journal writing. (Appendix 4I2, Monday, 30/3/1998, page 382)

Overall, from Category 1 of Appendix 4K (page 399), 20% of the respondents (with S2 included) sometimes found it difficult to articulate their teaching ideas in the journals; 10% could not finish writing the journals in class and 10% hoped that some guidance could be provided to assist them in reducing and surmounting the obstacles in writing journals. In Phase II of my study, I managed to find a way to respond to this feedback – namely by providing more specific guidelines and more time for self-articulation and reflection (pages 179-180: "Journal Writing" in the section "Recommendations for Phase II Implementation" in a later part of this chapter).

Discussions

A number of the student teachers (including S2 and S3) seemed to like group and class discussions. Category 2, 3 and 4 in Appendix 4K (page 399) shows that a total of no less than 30% of the respondents found both small-group discussion (70%, including S2 and S3, Category 2), presentation of the groups' ideas (90%, including S2, Category 3) and class discussion (40%, including S3, Category 4) all beneficial to learning. They remarked that they could learn from one another, especially in small-group discussion (60%, including S3, Category 2), but less so in whole-class discussion (30%, including S3, Category 4) and presentation of group's ideas (40%, including S2, Category 3). S2's and S3's remarks in their journals are informative:

> I...like group discussion because it is interesting and motivating and I can hear different voices about mathematics teaching. (S2's remark in his journal dated Monday, 9/3/1998, Appendix 4I2, page 380)

> I can also discover form observing others...my strengths and weaknesses, and hence I can improve my teaching. (S2's remark in his journal dated Monday, 30/3/1998, Appendix 4I2, page 382)

> I like the lecturer to use group discussion. In addition to stimulating individuals' thinking, the important interaction among group members makes members understand what has been overlooked in their articulated teaching, to express and share their opinions, to take in others' strong points and at the same time correcting individuals' own weakness....I also accept whole-class discussion...But class discussion should not be overdone because too much time is taken. (S3's remark in his journal dated Monday, 9/3/1998, Appendix 4J2, page 391)

The last paragraph demonstrated that class discussion was less favoured by S3 because he thought too much time was spent on it (there was another student who agreed with S3 that too much time was spent, see Category 7 in Appendix 4K, page 399), despite Class-97 members being able to learn from one another. This could also be the reason for his relatively lower score of 3.3 for the category LC in the CLE survey mentioned earlier (page 162; see also a later subsection on "Lecturer's Teaching", pages 167-168).

Two other possible reasons for student teachers not appreciating whole-class discussion could be: (1) that individuals could not receive appropriate attention in a whole-class discussion (10%), and (2) the topics under discourse could perhaps be so involving that time was insufficient to allow a thorough understanding of the main issues raised (10%). (See Category 4 in Appendix 4K, page 399.)

The idea of asking a student teacher to present the groups' opinions about teaching was particularly welcome, because the presentation activity could improve student teachers' power of expression (80%, including S3, Category 3 in Appendix 4K, page 399) and their confidence (60%, including S3, Category 3 in Appendix 4K, page 399):

> Allows us to teach, to train ourselves in teaching, and to develop our confidence. (S3's remark in his journal dated Monday, 9/3/1998, Appendix 4J2, page 391)

The foregoing perceptions and comments from both the Class-97 students and the Case-97 trainees witnessed the creation of a social constructivist learning environment that encouraged student teachers to discuss and to disclose their feelings. This finding also echoes the general positive findings for the learning environment in the CLE survey with respect to LS and LC (pages 161-162).

Change in Group Members

There was no consensus as to whether a member should stay in the same group throughout the whole module. About 40% of the respondents (including S2 and S3) indicated that they did not have any problem with changing members in a group (Category 2 in Appendix 4K, page 399). Within the Case-97 (excluding S1 who was absent on the day and she had not submitted the journal), both S2 and S3 liked this kind of arrangement too – S3's reason was that learning was facilitated, whereas S2 said that it provided the opportunity for making more new friends:

> I like to group ourselves into discussion groups, especially when we can talk with different people in different meetings. Discourse with different people with different thinking styles facilitates learning from others'

> experiences. (S3's remark in his journal dated Monday, 9/3/1998, Appendix 4J2, page 391)

> I actually like to have different members in my discussion group every time we meet because I can make new friends and more friends. (S2's remark in his journal dated Monday, 9/3/1998, Appendix 4I2, page 382)

Nevertheless, there were voices against the frequent change of group members (10% against changes in members, Category 2 in Appendix 4K, page 399).

Lecturer's Teaching

Student teachers made little comment in their journals on the lecturer's input during the various meetings (thus, interviews and post-teaching discussions would be appropriate; see later "Results from Case-97 Members' Post Teaching Discussions and Interviews", pages 168-170). Those who did referred mainly to the anticipated role of the lecturer. Acting as a mediator in settling disputes was expected by 20% of the respondents (Category 5 in Appendix 4K, page 399), and better apportionment of the time and content for discussion was the desire of 30% (including S3, Category 7 in Appendix 4K, page 400). In his 9 March 1998 journal, S3 wrote:

> The time for discussion is insufficient, thus reducing the effectiveness of the group interaction. The best method is to have an appropriate content for discussion, to set aside more time, or to arrange a suitable period of time for discussion. Extending the class meeting to cater for discussion is a feasible method. (Appendix 4J2, page 391)

S3's comments were all very positive. He commented that the learning activities were all effective, but if more time could be planned, or the class meeting could be extended for another half an hour, perhaps learning would be more effective (Appendix 4J2, page 391). These remarks could perhaps also explain why his average frequency scores for the categories of LL (3.0) and LC (3.3) in the CLE survey (Table 4.8, page 161) were relatively low – he found that he could not help the lecturer to decide on the kinds of activities the 2SC-97 students could do to enhance learning and their time allocation (which is LL), and he thought that there was an inadequate amount of time for student teachers to learn to explain and to listen to others' ideas about mathematics teaching (which is LC).

To summarise students' perceptions of the learning environment created in my methodology classes, the following extracts from the journals of S2 and S3 are quoted below:

> The past activities helped me tremendously; at least, I begin to know how to use expository and discovery method to plan a lesson. Moreover, I did not find attending the lessons boring. (S2's comments on learning activities and classroom learning environment in Appendix 4I2, Monday, 30/3/1998, page 382)

> All the learning activities...are of value to our learning. In particular, presentation, micro-teaching and group discussion are most valuable....Increase my confidence, give me a chance to understand my own inadequacy from the viewpoints of members of the class, and hence I can improve my teaching. In addition, experiences are also accumulated. (S3's comments of the learning activities in Appendix 4J2, Monday, 9/3/1998, page 391)

Results from Case-97 Members' Post-teaching Discussions and Interviews

The results of the post-teaching discussions after I observed the Case-97 students' classes during the teaching pracatice (Appendices 4H3, 4I3 and 4J3, pages 372-374, 383-386 and 394-396 respectively), and the interview data collected from these students at the end of the methodology module (Appendices 4H4, 4I4 and 4J4, pages 375-376, 387 and 397-398 respectively) provided further information about the classroom learning environment I created during the methodology period.

During the post-lesson discussion in the teaching practice, S2 commented on the teaching methods learnt in my methodology classroom:

> I found that the methods taught in your lesson are very useful. The teaching of concepts etc. Other materials learnt in HKIEd are of no use seemingly. (Appendix 4I3, page 384)

The following extracts from the Case-97 trainees' responses may perhaps indicate that the learning about pupils' learning (LP) would need to be reinforced – the Case-97 students had not been informed that pupils in secondary schools behave differently to expectation:

> The difference between what I imagined before and after the teaching practice is that pupils in fact lacked the motivation to learn and that an inexperienced teacher like I am cannot use the various teaching methods expeditiously. Thus, the real classroom teaching was not as I predicted. (S3's comment on pupils' motivation and his inability to use the learnt methods, Appendix 4J4, page 398: Answer to question 8)

> After the teaching practice, I find teaching mathematics much more difficult than expected....Pupils may not be willing to learn. They lack the motivation. (Appendix 4H4, page 376: S1's answers to questions 8 and 10)

> After the teaching practice, I have a different view about mathematics teaching. Pupils' motivation was weaker than I thought. (S2's comments about pupils' motivation, Appendix 4I4, page 387: Answer to question 8)

Overall, different forms of data collected from student teachers concerning my methodology class seemed to imply that a social constructivist classroom, with substantial opportunities for communicating and interacting, had been created (see summaries of findings on pages 161-163 and 168). However, further improvements needed to be made in the following aspects:

- relating activities more to the real school setting (e.g., CLE results about LP and LM, page 162; interview results, page 169)
- allowing more time for my students to construct their own methods in teaching junior secondary pupils of mathematics (e.g., pages 163-164: "Journal Writing"; pages 167-168: "Lecturer's Teaching"); and
- increasing my students' input in the shared control of their learning (e.g., S3's comments on LL, pages 167-168).

The next section reviews my critical friend's comments on the constructivist learning environment created to facilitate the learning of my Class of 2SC-97 students.

Phase I – Critical Friend C'S Comments

Because of the time constraint, I recorded two of the many discussions I had with C (Appendix 4L, pages 401-402). C commented on both my student teachers' learning and the constructed class learning environment in two of my lessons she observed (on 2 March 1998 and 1 June 1998).

C delineated the atmosphere in the session dated 2 March 1998 as one which favoured knowledge construction, because the lecturer was sincere and student teachers' attitude was positive. C also commented that when group discussion was organised at the start, there was a lot of student-student interaction and student teachers seemed to enjoy the discussion. However, as the group discussion proceeded, some of the student teachers became withdrawn and uninterested. Then, the student teachers all participated more actively again in the whole-class discussion (Appendix 4L, page 401). In the 1 June 1998 session in which student teachers were having their assessments (in the form of presentations), the Class-97 students was described by C as detached and uninterested at first, but the learning atmosphere became better gradually (Appendix 4L, page 402). C did not make any remarks on the journal writing – student teachers' self-reflection – but she stressed that the anticipated role of the lecturer as an expert in teaching could not be observed at all.

C's observation seemed to be in agreement with those generated from the student teachers' data discussed earlier, particularly with reference to discussion in groups and in class (pages 164-166). However C perceived that student teachers' learning was not as positive. Learning was not effective and was difficult to evaluate. C gave two key observations: (1) inadequate subject matter knowledge on the part of the student teachers, and (2) their insufficient participation in class discussion that could assist learning:

> However, since the student teachers did not have adequate knowledge about the mathematical concepts, their attention was directed mostly to discussing the concepts more than to the teaching approaches....It is difficult to evaluate the learning outcomes of this lesson. (Appendix 4L, Monday, 2/3/1998, page 401)

> The class could learn very little from a poor presentation....Some of the student teachers did not participate actively in the whole-class discussion. (Appendix 4L, Monday, 1/6/1998, page 402)

Based upon these remarks, the seemingly unchanged teaching orientation and beliefs about teaching mathematics of the Class reported and discussed in the previous sections (e.g., pages 157-160: Overall results) could possibly be explained. However, I do not fully agree with C's viewpoints. While I concur with the second point she raised, I have reservations about her view that my students' mathematics knowledge was inadequate. All these student teachers have a pass in the Advanced Level mathematics (see Table 3.3, page 87), and I would have no doubt about their understanding of mathematics concepts covered at the junior secondary level. The observation that student teachers concentrated their discussion firstly on clarifying the mathematics concepts should not be interpreted as their incompetence in mathematics. Rather, I consider this a proper first step for preparation to teach any particular concept.

Student teachers' inadequate participation in group discussion on the teaching methods to be used could be due to the fact that these student teachers lacked the relevant teaching experience and pedagogical knowledge; consequently, they found it very difficult to articulate and express their teaching ideas. In response, I decided to use more time to take these learners through the various stages espoused in my constructivist model in Phase II. As they moved through the constructivist learning process, they would more easily realise any inadequacies in their knowledge about teaching. This would hopefully provide better incentives for them to change and develop new learning. (See Appendix 4C, Monday, 2/3/1998, page 338.)

My impromptu and unsystematic input was perhaps another possible reason for the ineffectiveness of student teachers' learning, according to C:

> The lecturer seemed to give impromptu remarks and comments. It is different from what I expect of an expert input. (Appendix 4L, Monday, 2/3/1998, page 401)
>
> Comments on the presented teaching approach were not systematic....There was mainly student-student interaction. Lecturer and students' communication with each other was only one way – from lecturer to the student teachers. Few student teachers tried to interact with the expert. (Appendix 4L, Monday, 1/6/1998, page 402)

These two comments initiated my rethinking my role as facilitator and mediator in the social constructivist learning environment. Very often, both planned and unplanned (events and) queries would occur in every class meeting. My belief (and consequent practice) is to ask further questions in order to initiate or lead further discussion, and as far as possible, I would try not to supply a direct answer – there are no definitive answers to most questions regarding teaching mathematics. Yet, it is true that I need to strike a balance between the two roles – a facilitator and an expert. In future, I have to reconsider the right amount of intervention, the kind of input, and the appropriate time to intervene and to sit back and listen. Some guidelines for my students in preparing and presenting their teaching ideas should also be planned (Appendix 4C, 2/3/1998 and 1/6/1998, pages 339-340 and 347 respectively).

Overall Results (Constructivist Learning Environment, 1997-98)

This subsection summarises the positive and negative findings obtained with respect to the learning environment created in the methodology classroom. I cautioned myself to take into consideration the full range of student teachers' perspectives and to be careful to interpret the evidence because of its basis in one class (and three Case-97 students) only.

Positive Outcomes

- From the results in the CLE questionnaire, the 2SC-97 students (including S1 and S2) found ample opportunities for learning to communicate with one another and to negotiate with their peers (LC) (pages 161-162).
- The CLE results indicated that student S2 gave particularly high scores to all the five categories of learning in the classroom. He perceived plenty of opportunities to learn about the teaching methodologies (LM) and about his pupils' learning (LP), and to negotiate with his peers (LC), to understand (LS) and to share control with me in his own learning (LL) (page 161).

- The CLE results implied the 2SC-97 students (including all the Case-97 students) perceived that opportunities to express critical opinions (LS) of the learning environment occurred often (pages 161-162).
- Half of Class-97 members (including S2 and S3) found journal writing helpful in learning (see results from journals, pages 163-164: "Journal Writing").
- Over 70% of the 2SC-97 students (with S2 and S3 included) welcomed group discussion and presentation, because they agreed that the activities helped learning (see results from journals, page 164: "Discussions").
- All the Case-97 students gave positive comments in their journals, in the post-lesson discussions and during the interviews on the learning environment: interesting, confidence building and useful for learning (pages 165-169).

Negative Outcomes

- Student teachers had different perception of opportunities for learning about their pupils' learning (LP) and for learning about methodologies (LM). The frequency of occurrences of the opportunities varied from sometimes to often (as indicated by the CLE results, page 162; the journal entries by S2 and S3, page 168; and discussion and interview results, pages 169-170).
- The student teachers (with S1 and S3 included), from the CLE results, had the common perception that there were not enough opportunities for sharing control of their learning activities with me (LL) (pages 162-163).
- Students (20%, including S2) found difficulties in articulating teaching ideas. Guidance was required (10%). (See results from journals, page 164: "Journal Writing").
- Whole-class discussion was less favoured by the 2SC-97 students (40%, including S3, see results from journals, page 164: "Discussions").
- Insufficient time was available for discussion (20%, including S3, see results from journals, pages 165-166: "Discussions").

- Better apportionment of time and content would be necessary (30%, including S3, see results from journals, page 167: "Lecturer's Teaching").
- Critical friend C also described the learning environment as being conducive to frank and friendly discussion at first – students seemed to enjoy the group discussion – but later she found student teachers uninterested and withdrawn (pages 170-171: "Phase I – Critical Friend C's Comments").
- Learning was not effective; student teachers lacked subject matter knowledge and active participation (C's comment, page 171).
- My input was not systematic (C's comment, page 172).

In the next section, I will make recommendations for the Phase II implementation, not only on the basis of the foregoing results and discussion regarding both beliefs about teaching mathematics and the constructivist learning environment, but also on the basis of my observations and reflections during the Phase I implementation (see my record of lessons and reflections in Appendix 4C), and on my retrospective reflection.

RECOMMENDATIONS FOR PHASE II IMPLEMENTATION

As seen in earlier sections (e.g., pages 173-175: "Overall Results (Constructivist Learning Environment, 1997-98)), there is data that both supported and threw doubt upon the plausibility of employing a constructivist pedagogy in my methodology class in the academic year 1997-98. The social constructivist teaching model I initially put into practice comprised four stages (1) problem posing, (2) self-articulation, (3) constructing and reconstructing ideas and (4) self-reflection, with particular emphasis on the creation of a non-threatening environment that encouraged open discourse. Changes were made in its second trial, based on the findings obtained. In Chapter Three, these changes have been reported and briefly explained (pages 101-108); a comparison between the Phase I implementation and the corresponding changes has also been summarised in

Table 3.9 (page 102). In the following, I will try to justify the changes in the Phase II implementation.

Language

My 2SC-97 students, as mentioned earlier (e.g., Chapter Three, pages 76-77), are Chinese youths taking a Chinese-medium course in which the language of instruction, and consequently student teachers' class interaction, is in Chinese. However, I was using learning materials and questionnaires that were all written in English. In the second phase of my research, I decided that both the questionnaires and the learning materials should be translated into Chinese; the versions were reviewed by a translator to ensure that meanings conveyed were correct (e.g., Chapter Three, pages 102-103: "Language").

During the first class meeting (16 February 1998) in Phase I, I found that the completion of the questionnaires by the 2SC-97 students took considerable time (Appendix 4C, page 334). There were difficult concepts in education, for instance, "rote-learning" and "attributes", and the English had to be explained too – item by item and word by word. The same happened in the last session (Appendix 4C, 22/6/1998, page 350) in which I had to explain to my student teachers the questionnaires item by item, in Chinese. As time was insufficient (seen from various places in student teachers' responses, e.g., pages 174-175: "Negative Outcomes"; from my record in Appendix 4C, e.g., pages 334, 338) for my methodology module, I had hoped that I could spend little time in explaining difficult terms. I also anticipated that the translated version of the questionnaire would be more comprehensible by my student teachers, hence ensuring that the data collected in the next implementation phase would be more reliable.

Similarly, using worksheets which were in Chinese could also help my students to know exactly what to articulate and to present in class discussion. As mentioned earlier, I found inappropriate teaching methods in student teachers' journals, and this happened continually in a few consecutive class meetings (e.g., see Table 4.4, page 130). There were several possibilities – that the topics were difficult to articulate, or that my students were not motivated (C perceived them to be uninterested and detached from the Class, e.g., page 175: "Negative Outcomes"). It was very likely that the student teachers were uncertain how to proceed in the class meetings because of the English language used in the worksheets.

Learning

Student teachers seemed to enjoy both journal writing and discussions in constructing and reconstructing their teaching ideas (e.g., page 174: "Positive Outcomes"). Such feelings were not only evidenced in their journals discussed earlier, but were also confirmed in my own observation throughout most meetings. For instance, on Monday, 23 February 1998, I wrote:

> Student teachers seemed to be happy with the conduct of the meeting. Some told me during the meeting that they felt relaxed and commented that if every meeting was like this one, then this would be very good for their learning. (Appendix 4C, page 336)

Student teachers actually told me their feelings about self-articulation and group discussion that had a positive effect on learning:

> The more the discussion and debate, the more we can see clearly the teaching method. (By a student teacher, Appendix 4C, Monday, 2/3/1998, page 338)

> I like writing the journal and I have made an effort. This allows me to see clearly my teaching method. (By another student teacher, Appendix 4C, Monday, 2/3/1998, page 338)

Though writing and discursive activities seemingly facilitated learning, there were less positive results about my student teachers' learning. As mentioned in this chapter already, for instance, the scores for the CLE survey indicated that student teachers perceived few opportunities for their learning about their pupils' learning (LP), the methodology (LM) and their own learning (LL) (e.g., page 174: "Negative Outcomes"). The critical friend, C, actually found little or no learning in the classroom (e.g., page 175: "Negative Outcomes").

Topic for Self-articulation

The problem-posing stage – the first stage in my teaching model – emphasised the relevance of student teachers' experience (Chapter Two, page 44). However, in reviewing my record of teaching in Phase I, I found that my practice seemed quite to the contrary. For instance, I had chosen five "new" concepts – prime factorised, evener, odders, and so forth, as a kind of challenge, for student teachers' articulation in the first meeting. (When a positive integer is written as the product of primes, it is "prime factorised". If the number of primes in the product is even, the positive number is called an "evener"; similarly for an "odder". For further explanations, see Appendix 4C, Monday, 23/2/1998, page 336.). These are concepts uncommon in the junior secondary mathematics classrooms, and the to-be-articulated topics were not related to the junior secondary pupils' learning. This was probably the reason for student teachers' perception that there were few opportunities created for learning about pupils' learning (LP) in the CLE survey (page 174: "Negative Outcomes").

Concept teaching activities are also unfamiliar to student teachers. Current school mathematics teaching in Hong Kong is by way of direct teaching, stressing acquisition of skills, rules and procedures, and there is a paucity of teaching activities relating to the learning of concepts. Inexperienced student teachers have no knowledge about concept teaching, and hence articulating concept teaching activities (for three consecutive meetings, e.g., see Table 3.1, page 79) was perceived as irrelevant to their learning. Topics for discussion in the second phase consequently started with self-articulation of the teaching of a mathematics skill that is familiar to my students (e.g., see Chapter Three, page 106, Table 3.11).

Journal Writing

In their journals, a number of student teachers expressed the view that they had difficulty in self-articulation and self-reflection, and that they spent quite some time on these matters (e.g., pages 174-175: "Negative Outcomes"; my observation in Appendix 4C, Monday, 23/2/1998, page 334; Monday, 2/3/1998, page 338). It appeared as if the limited time given for journal writing in the Phase I classroom impeded a thorough and an intelligible self-expression about teaching.

Two other different views regarding journal writing were obtained in an informal meeting with two student teachers as recorded in Appendix 4C, Monday, 23 February 1998 (page 337). One student teacher prepared to do it at home, whereas the other preferred to finish the journals during the class meetings. However, I refrained from asking all student teachers to write their journals at home for fear of demanding too much extra time from my students (in assisting to generate data for my research study) and I considered it ethically unsound. Yet, this arrangement in finishing journals in class meetings may be one of the reasons for the low score for LL in the CLE questionnaire (e.g., see page 174: "Negative Outcomes"), which indicated less flexibility for my students in controlling their own learning.

The time-constraint problem in journal writing could be solved had I prepared more specific guidelines for self-articulation and reflection (and allowing more time for these and other learning activities; see Chapter Three, pages 103-104: "Number of Discussion Topics"). My observations during my students' presentations, my interpretation of students' journal entries, and my observations of the Case-97 students' teaching in class informed me that student teachers often overlooked the three key issues that I consider paramount in preparing for the actual classroom teaching, namely, (1) a clear statement of the teaching sequence, (2) provision of examples, non-examples (see Chapter Three, page 104, for explanation) and exercises used in the process of teaching, and (3) the accompanying important points to be stressed either orally or verbally (see Appendix 4C, from Monday, 25/5/1998 to Monday, 22/6/1998, pages 346-350; see also pages 337, 339, 341, 345).

Because teaching is a very complicated task, restricting the agenda for group and class discussion to the above three important points could better apportion the time and content in a two-hour session – it was also requested by some of my students in their journals (e.g., page 175: "Negative Outcomes"). A better focus on issues about teaching mathematics could also be provided. My students, being Chinese learners, would probably also favour the provision of more detailed guidelines for self-articulation and self-reflection (as well as for their formal assessment) (see Chapter Three, page 83: "The Period Before Class Assessment").

As mentioned in Chapter Three (e.g., page 102, Table 3.9), in Phase II, the journals were collected twice – after self-articulation and also after self-reflection – in a particular class meeting in order to determine the changes in beliefs of my students in teaching mathematics in that particular session. In Phase I, student teachers had not been requested to indicate whether their teaching ideas were self-articulated at the beginning of the meeting or whether they were constructed after the defence and negotiation (e.g., see Chapter Three, page 104: "A Form for Self-articulation and Reflection"). Changes in beliefs, if any, could hopefully be investigated in the second phase.

The Number of Topics for Class Discussion

In order to have more time for journal writing as well as for more in-depth discussion of particular teaching activities, the number of topics chosen for class discussion in a particular meeting was restricted to only one in Phase II (see Table 3.9 in Chapter Three, page 102).

In Phase I, different groups of student teachers were assigned different topics for discussion (see Chapter Three, page 103: "Number of Discussion Topics"). When different groups discussed and presented their viewpoints about mathematics teaching, student teachers again saw no relevance to what they had been doing (LP) (page 174: "Negative Outcomes"). Teaching of "the others' topics" had not been thought through, and provision of constructive comments and hence student teachers' learning might not be effective (LM) (pages 174-175: "Negative Outcomes").

The two student teachers with whom I had an informal meeting (Appendix 4C, Monday, 23/2/1998, page 337) commented that there were too many topics for discussion, and my feeling was likewise:

> The five topics were too much for them. It was not easy to generalise the teaching methods all at once in so short a time. (Appendix 4C, my remarks on Monday, 23/2/1998, page 337)

S3 also urged me to extend the meeting to two-and-a-half hours in order that we could have more time for class discussion, as mentioned earlier (pages 167-168: "Lecturer's Teaching"). (See Chapter Three, pages 103-104: "Number of Discussion Topics", for an increase in the amount of time for the various learning activities in Phase II.)

Group and Class Discussion

While the group and class discussion in Phase I were generally active (as C had commented; see page 175: "Negative Outcomes"), I had also found students were uninterested at times (e.g., Appendix 4C, pages 336, 341, 346). When presenting the groups' teaching ideas, it was the presenter who did all the talking; the other members of the group remained silent and probably detached. Since group (and class) discussion is a vital process in constructing and reconstructing teaching ideas in my model of teaching, I tried to involve all student teachers in the group discussion as far as possible.

The choice of membership in a group was still voluntary, but the change in membership in the group was abandoned in Phase II (see Table 3.9, page 102). There was no change in group members, and everyone in the class was required to stay in the same group throughout the module. Though I encouraged sincere discourse in group (as well as in class) discussion, and some of the student teachers preferred to have different new friends in a group every time they met (pages 166-167: "Change in Group Members" in this chapter), I also considered the development of friendship vital in the group, especially as my students are Chinese. It was my hope that as friendship developed in the same group, a sense of belonging to that group would also be fostered (Chapter Two, page 49: "The Impact of Harmony on Class Interaction").

The presenter who represented the group was also the chair of the class discussion in Phase II, whereas in Phase I, I acted as the chair (Chapter Three, page 82). I hoped that in the second phase, discussions among group members would be more open and involve less self-effacement. All members would be expected to participate – for the benefit of the group to which they belonged. This arrangement was aimed at supporting group harmony, which was a key issue reviewed in the literature about Chinese student learning (Chapter Two, pages 49-51: "The Impact of Harmony on Class Interaction") in relation to assisting individuals' learning.

Lecturer Intervention and Input

It seemed that I did not perform satisfactorily in the methodology classroom. According to C, she could not recognise my role as an expert during her two observations, and she attributed student teachers' ineffective learning to my impromptu input (page 175: "Negative Outcomes"). From my record of lessons, I did act as an expert in delivering teaching methods in class meetings (e.g., Appendix 4C, Mondays 9/3/1998 and 16/3/1998, pages 340-341), despite my belief that pertinent questions rather than direct answers might create perturbations in students and lead to belief change.

During one of the class sessions, student teachers expressed their wish that I should teach them directly the methods about teaching mathematics. In my record of lessons, I wrote:

> They would like me to teach how to teach rather than organising discussions. (Appendix 4C, my remarks on Monday, 23/2/1998, page 337)

In the next phase of study, I tried to organise my plans of teaching more carefully, and I decided to intervene in discussions more often, provided that the situation was appropriate – for my Chinese students would presumably like to be taught (e.g., Chapter Three, pages 83-84). Furthermore, I also preferred to give my students the impression that I had my lessons so well prepared that attending my methodology class would not be a waste of their precious time.

Briefing on Assessment

In Phase II, there were two changes, as mentioned in Chapter Three in the briefing on assessment (see page 107 in the subsection "Class Meeting Schedule"). Lot drawing was not carried out during the class meeting in order to avoid spending too much time on this unrelated chore – it had given the Chinese students the impression that I did not prepare my lessons. Briefing on assessment activities was delayed to some later sessions and not covered in the first meeting, because from my record of lessons (Appendix 4C, Monday, 16/2/1998, pages 334-335), I had spent considerable time in explaining this. In the next phase, my students would be more familiar with the assessment procedure after attending a few class meetings – which resembled, to a certain extent, the presentation part of the assessment task.

The next chapter addresses the Phase II results obtained when improvements to my teaching and data collection methods had been carried out.

CHAPTER FIVE

RESULTS AND DISCUSSION (PHASE II)

INTRODUCTION

Changes made in the Phase II study and the underlying rationale for improvements were reported in Chapter Four (pages 175-183). It seemed that the constructivist learning environment I envisaged had been implemented rather inflexibly in my class of first-year Chinese student mathematics teachers in 1997-98 (see Chapter Four, pages 173-175: "Overall Results (Constructivist Learning Environment, 1997-98)"). I realised that it would be inaccurate to claim that these students of mine really held a social constructivist perspective towards teaching mathematics at the conclusion of the methodology module (see Chapter Four, pages 156-160: "Overall Results (Teaching Beliefs, 1997-98)"). In the second phase of my research, all learning materials and research instruments were translated into Chinese and vetted by a translator (see pages 176-177: "Language"). Self-articulation and discussion was more focused – only one topic for the whole class was assigned – and more time was allocated to each activity in the social constructivist model (see pages 177-178: "Learning"; page 178: "Topic for Self-articulation"; pages 180-181: "The Number of Topics for Class Discussion"; page 183: "Briefing on Assessment"). To cater for the Chinese learner characteristics, improved guidelines for reflection and articulation were prepared for use (see pages 179-180: "Journal Writing"); members stayed in the same group throughout all the class meetings (see pages 181-182: "Group and Class Discussion"), and I attempted to make my input timely and precise rather than impromptu (see pages 182-183: "Lecturer Intervention and Input").

Again, as in Chapter Four (page 114), this chapter reports the results and discusses them with respect to two broad issues: (1) student teachers' beliefs about mathematics teaching and (2) the creation of a social constructivist environment for student teacher learning.

PHASE II – STUDENT TEACHERS' TEACHING BELIEFS

Student participants in this phase were also first-year Chinese student teachers; they enrolled in the academic year 1998-99, again taking the same methodology module which I used in Phase I of this study (see Chapter Three, page 101: "Phase II: My Teaching"; page 108: "Phase II: Sample Details"). The two hours per week course extended from Thursday 28 January 1999 to Thursday 17 June 1999 (see Chapter Three, pages 106-107: "Class Teaching Schedule").

As with the Phase I findings (see Chapter Four, page 115), I report on the beliefs about teaching mathematics held by my 2SC-98 students (hereafter 2SC-98 or Class-98 always referred to include the Case-98 students: E1, E2 and E3) on the basis of the data collected from the Beliefs About Teaching Mathematics (BTM) survey, the General Teaching Sequence (GTS) questionnaire, student teachers' journals, classroom observations and interviews. Meanings and interpretations were created as I reflected retrospectively on the data and on my experiences (e.g., see my record of lessons and reflections in Appendix 5A, pages 403-428). Information that both supported and challenged my interpretations was examined.

Results from the BTM Questionnaire, 1998-99

Student teachers' responses to the BTM questionnaire (which can be found in Appendix 3C, pages 320-322) were collected when the methodology module commenced (28 January 1999) and after it ended (17 June 1999). Appendices 5B (pages 429-430) and 5C (pages 431-432) contain respectively pre- and post-module records of overall mean scores and mean scores for individual items by the Class-98 students, and in particular, scores for individual items by the Case-98 students were tabulated. The overall teaching orientation and categorised teaching beliefs held by the Phase II student participants were determined by analysing and comparing the pre- and post module results (see Chapter Four, page 116).

2SC-98 Overall Teaching Orientation

Table 5.1 compares the pre- and post-module overall average agreement scores (and the standard deviations) by Class-98 members and by the Case-98 trainees for all the items in the BTM questionnaire.

Table 5.1
A Comparison between the Pre-module and Post-module Overall Means of the Beliefs About Teaching Mathematics (BTM) Survey, Phase II, 1998-99 (N = 15)

		Case-98[b]		
	Class-98[a]	E1	E2	E3
Pre-module				
Mean	3.6[c]	3.7	3.5	3.5
SD	0.9	1.2	0.8	0.9
Post-module				
Mean	3.6	3.6	3.5	3.3
SD	1.0	1.1	0.9	0.8

Note.
Responses were made on a 5-point scale (5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, 1 = strongly disagree).
[a]15 returns out of 20. [b]Case-98 consisted of three outstanding student teachers E1, E2 and E3 chosen from Class-98; their responses were also counted in the calculation. [c]One student teacher gave no response to item 18.

The overall means of members of the Class-98 and of the Case-98 (both at or above 3.5) indicated that the pre-module beliefs of the 15 respondents out of a class of 20 2SC-98 students were more inclined towards learner orientation (see interpretation by Van Zoest et al., 1994, pp. 42, 44, 47; see also Table 4.1, page 117). This implied that they would prefer the use of an approach which facilitated pupils constructing their own mathematical knowledge rather than emphasising mastery of rules and procedures.

The post-module means scored by the 2SC-98 students, by E1 and by E2 still reflected a learner-focused approach to teaching mathematics; but the mean score of E3 indicated that he was inclined slightly towards a content-understanding teaching orientation (according to Van Zoest et al., 1994, pp. 42, 44, 47; see also Table 4.1, page 117).

The calculated standard deviations (approximately 1.0) were indicative of differences in beliefs (according to Van Zoest et al., 1994, p. 47). This suggested that within the Class-98, variations in teaching beliefs existed among students, and likewise for each student in the Case-98. This finding is similar to the findings in Phase I.

The overall Class mean agreement scores for the two phases are also compared. Table 5.2 compares the averages, and hence the signalled changes in dispositions to teaching – possibly a result of my teaching. In the second phase of implementation, the 2SC-98 Class seemed to show no change in their (constructivist) teaching beliefs, whereas the 2SC-97 Class appeared to change their original (constructivist) beliefs towards the more teacher-centred approach.

Table 5.2
A Comparison between the Two Classes of Students' Overall Means of the Beliefs About Teaching Mathematics (BTM) Survey in the Two Phases of Implementation

	Overall Mean Score of the Class (SD)	
	Pre-module	Post-module
Phase I, 1997-98	3.6 (1.0)	3.4 (1.1)
Phase II, 1998-99	3.6 (0.9)	3.6 (1.0)

Note.
Responses were made on a 5-point scale (5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, 1 = strongly disagree).

The categories of teaching beliefs of the 2SC-98 students will be discussed in the next subsection.

2SC-98 Different Teaching Beliefs

As in Phase I (Chapter Four, pages 116-119), the 33 items in the BTM Survey were grouped into nine categories of beliefs about mathematics teaching.

Appendices 5D (pages 433-435) and 5E (pages 435-437) show respectively the pre- and post-module mean scores of individual items by the Class-98 students and individual scores by Case-98 members. Items marked with an asterisk were constructed in the content-focused sense and their scores had been reversed (see also Chapter Four, pages 116 and 119). The paragraphs below present the results and discuss their implications.

(1) Role of a Mathematics Teacher

The post-module findings resembled the results in the pre-module BTM survey. All Class-98 members (including the Case-98 students) believed that the key responsibility of a mathematics teacher was to create opportunities for pupils to explore freely their own mathematical ideas (item 1). The creation of such a non-threatening environment (item 6) was still scored high among all the 33 items – the 2SC-98 students continued to believe that a risk-free environment was vital in learning mathematics.

(2) Questioning

Findings concerning the post-module responses were again similar to the pre-module responses. Questioning was still regarded as important for effective mathematical learning (item 14).

(3) Mathematics Content

The unanimous beliefs exhibited by the student teachers at the end of the methodology module were very similar to those held by them at the start of the module. Probably Class-98 members believed that there was a core of mathematics content which had to be taught (item 26, with scores reversed) in a particular proper order (item 32, with scores reversed), though the sequence might not necessarily be similar to that stipulated in the textbook (item 18, with scores reversed).

There was one point in the results worthy of highlighting. E3, who originally strongly supported the notion that it was unnecessary to cover all the mathematics topics in the textbook sequence (item 18, with scores reversed), queried this idea at the end of the methodology module. In other words, E3 became more content-inclined by the end of the methodology module than he was at the start.

(4) Problem Solving

Unanimous, seemingly stable but contradictory beliefs in both pre- and post-module results could also be found in this category. All the student teachers agreed that a vital task for the teachers was to motivate their pupils to solve their own mathematical problems (item 5), but they were not sure if it would enhance learning by confronting their pupils with more demanding problems (item 29). The latter result could mean that the 2SC-98 students apparently did not understand the idea that belief changes, and hence learning, could be facilitated by confrontation and tension.

Furthermore, the 2SC-98 students believed that it was unnecessary to provide the pupils with solutions to these problems (item 10, with scores reversed). However, they also considered that they should provide clear and concise solutions (item 23, with scores reversed) – contradictory to their responses to item 10. It is possible that the class preferred the teacher to avoid providing learners with solutions to mathematical problems. Should they have to do so, they would rather provide a clear and simple method of solution to facilitate learning.

(5) Group Interaction

Student teachers also showed unanimous and stable beliefs – that is, learner-interaction beliefs – in this category throughout the methodology module. They agreed with the idea that pupils could learn more mathematics by working together (item 27) and through discussions (item 31). Thus they supported that the notion they should provide opportunities for pupils to investigate in small groups (item 19) and for individuals to undertake self-reflection and self-evaluation (item 25). Similar to the pre-module situation, they could not decide whether their pupils could learn best if left alone (item 12, with scores reversed) – an idea which seemingly contradicted the views displayed in the responses to the other items in this category. One possible explanation could be due to students' lack of sufficient experience in group learning. Since the commonly used teaching method in Hong Kong is the traditional approach (see Chapter One, pages 2 and 9-11), student teachers were very likely to have had little or no experience in learning mathematics together in small groups. Thus it was understandable that student teachers could not compare the effectiveness of the two modes of mathematics teaching – working together and individual learning; hence the undecided response.

There was one area of contradiction in E1's beliefs worthy of highlighting. In regard to whether mathematics is best learned individually (item 12, with scores reversed), E1 changed his response from undecided in the pre-module BTM questionnaire to supporting this view strongly. He appeared to be outwardly rejecting the social construction of knowledge perspective, which he supported in his responses to the rest of the items in this category – he even showed strong support for learning by discourse (item 31, with scores reversed) before the methodology module commenced and after it ended. Possibly, E1 was not against social construction of knowledge and yet he considered individual construction of mathematical ideas also paramount. Further investigation of student teachers' beliefs by means of journal entries and interviews were appropriate (see, e.g., pages 205-216: "Case Members' Beliefs About Teaching Mathematics, Phase II, 1998-99").

(6) Teacher Exposition

Average scores by Class-98 members for the four items included in the teacher exposition category indicated no appreciable changes in the overall pre-module learner-focused beliefs, although the scores were relatively lower in the post-module results. However, scores for different items portrayed unstable and contradictory teaching beliefs. Student teachers still believed that understanding the source of their pupils' errors would assist changing pupils' misconceptions (item 21, with scores reversed). Yet they displayed contradictory views about the effectiveness of exposition in teaching mathematics. On the one hand, the Class-98 students changed to agree that the "teacher-talk and pupil-listen" mode could not be the most effective way to learn mathematics (item 11, with scores reversed); whereas they were undecided about whether telling pupils the answers and using expository teaching were effective means of teaching mathematics (items 22 and 30, with all scores reversed).

E2, who appeared to possess a constructivist outlook in the first session, gave me the impression of becoming more didactic in the last session of the methodology module. Though her response to item 22 (with scores reversed) showed that she was still against telling pupils the answers to problems, her original apparently firm belief that the expository approach was ineffective had been shaken (as denoted by her responses to items 11, 21 and 30, with all scores reversed).

E1 displayed a less content-focused inclination to teaching mathematics at the end of the methodology class. Although his responses to the BTM in this post-module stage showed that he supported the telling of answers to facilitate pupil learning (item 22, with scores reversed), he did not support expository teaching as an effective means in mathematics learning (items 11 and 21, with all scores reversed).

The scores in E3's responses to the items in this category indicated a change towards the more learner-focused belief. He became more convinced that exposition alone could not possibly enhance mathematics learning.

(7) Personal Construction

At the end of the methodology class, the 2SC-98 students still remained superficially unchanged in acknowledging the fact that their pupils had different interpretations of a mathematical idea. This was revealed from their scoring a mean of about 4 in several items (items 2, 3, 7, 8, 15, 17, where scores for items 7 and 17 were reversed) in this category of teaching beliefs. Yet the Class admitted that they could not decide whether acknowledging different perspectives of mathematical thinking was inefficient and might confuse their pupils (item 4, with scores reversed). They were also uncertain as to whether it was important for their pupils to justify their own mathematical statements (item 33). This finding – student teachers possessed stable but contradictory teaching beliefs – had been evidenced, for instance, in discussing the two foregoing categories of beliefs about problem solving and group interaction (see Categories 4 and 5, pages 189 and 189-190 respectively).

The Case-98 students, resembling students of the Class-98, were also undecided as to whether it would be inefficient and confuse their pupils to recognise the different ways of mathematical thinking displayed by their pupils (item 4, with scores reversed). Similarly, they could not decide whether justifying the statements one made was an important part of mathematics (item 33). Other than these two similarities, the Case-98 students seemed to hold less strongly the belief that their pupils actually constructed their own ideas differently from one another. In particular, E3 apparently could not determine if such an idea of personal construction could be true, because the number of items in this category with a score of 3 was slightly more than those whose scores were 4.

(8) Teaching and Learning Mathematics

Case-98 members generally displayed similar findings comparable to those of the Class-98 students in the pre- and post-module responses to items 9 (with scores reversed) regarding the learning of mathematics and items 16 and 28 regarding the role of teachers in understanding the nature of mathematics. The Class-98 students, on the whole, still believed that learning mathematics did not need to involve considerable memorisation (item 9, with scores reversed), but they were uncertain (whereas the Case-98 trainees were certain) whether they could solve problems in mathematics without using rules or not (item 24). They also agreed unanimously (and remained unaltered in their beliefs) that effective mathematics teachers should enjoy learning mathematics (item 16) and try to understand the structured way in which mathematics concepts and skills relate to one another (item 28).

Both members of the Case-98 and the Class-98 responded similarly to item 13 (with scores reversed) in the post-module result, whereas previously they were quite different. At the start of the methodology module, Class-98 members and E1 seemed to believe that mathematics was mostly made up of related topics, but E2 and E3 were undecided at that stage. At the conclusion of the methodology module, however, with only E2 still undecided, the whole class appeared to believe otherwise – they did not support the idea that topics in mathematics were related in some way. With increasing familiarity with the current mathematics syllabus and some experience in teaching it, student teachers seemed to change their beliefs about the content and the nature of the mathematics they would be prepared to teach.

One point worth highlighting was the change in E3's beliefs about teaching and learning. In his pre-module responses, E3 showed indecision in almost all the items grouped under this category (four out of five items), except in supporting the importance in understanding that mathematics is made up of connected skills and concepts (item 28). After the methodology module, E3 was more certain about the dispensability of both memorisation and the use of rules in learning mathematics (items 9 and 24, where scores for item 9 were reversed). He still supported the proposal that mathematics teachers should be well versed in the mathematical structures (item 28), but he then disagreed with the proposal that mathematics was made up of related topics and skills (item 13, with scores reversed).

(9) Teacher Change

Class-98 members and E1 still supported the idea that an attitude of inquiry should be developed in the process of teaching (item 20); E2 changed to concur with the Class-98 students and E1 at the conclusion of the module. E3, on the other hand, changed from originally supporting the idea to disagreeing with it at the end of the module.

Summary (BTM Results, 1998-99)

As in Phase I (Chapter Four, pages 144-146), I will give a comparative summary (Appendix 5F, pages 439-440) of student teachers' pre- and post-module beliefs about mathematics teaching, on the basis of the results of the two BTM surveys. In the appendix, belief statements are re-written in the learner-focused sense. Agreement scores are converted to "ticks" – one "tick" represents "agree" and two "ticks" "strongly agree"; a blank space in the response indicates either "undecided" or "disagree".

From Appendix 5F (pages 439-440) and the foregoing discussion about student teachers' various beliefs about teaching mathematics (pages 185-194: "Results from the BTM Questionnaire, 1998-99"), the Class-98 students, though displaying an overall stability in their (learner-focused) teaching beliefs (pages 186-194), also showed disagreement with or uncertainty (and sometimes contradictory viewpoints) about the (constructivist) belief statements in the categories of mathematics content (Category 3, page 439), problem solving (Category 4, page 439), group interaction (Category 5, page 439), teacher exposition (Category 6, page 439), personal construction (Category 7, page 440) and teaching and learning mathematics (Category 8, page 440). The Class-98 trainees were still undecided about the sequence of presenting the content and the appropriate amount of mathematics to be presented (Category 3, pages 188-189, 439). Should it be teacher explanation and pupil listening? Was telling the answers effective (Category 6, pages 190-191, 439)? Student teachers wondered whether or not it was necessary for them to create situations that made pupils feel uneasy or even a little tension in order to facilitate learning (Category 4, pages 189, 439). They decided that it was unnecessary to provide solution methods to their pupils, but if they had to, they determined to provide clear and concise solutions (Category 4, pages 189, 439). Furthermore, the Class-98 students believed that group interaction facilitated learning, but mathematics was best learnt individually (Category 5, pages 189-190, 439). They maintained that their pupils developed idiosyncratic mathematics knowledge, but that acknowledging and justifying these individual ideas in class might cause confusion and impeded learning (Category 7, pages 192, 440). Regarding the nature of mathematics (Category 8, pages 192-194, 440), the 2SC-98 students still possessed the belief that learning mathematics needed no memorisation, and they remained uncertain whether mathematics problems could be solved without using rules. However, students changed to believe that mathematics topics were disconnected. These findings generally resembled those for the 2SC-97 students (see pages 144-146: "Summary (Post-module BTM Results, 1997-98)"); and all of these issues require rethinking in future programmes in mathematics teacher education.

Results from the GTS Questionnaire, 1998-99

Similar to the BTM survey, the GTS questionnaire (found in Appendix 3E, page 324) was also administered twice – in the first (28 January 1999) and in the last session (17 June 1999) of the methodology module (see Chapter Three, Table 3.14, page 110) – to discover student teachers' preferred teaching sequence(s) which I believed could reflect their teaching orientation. At the same time, I investigated whether there were any belief changes at the end of the module.

Student teachers were asked to give their preferred teaching sequence(s) in the GTS questionnaire; there were 15 returns (including the Case-98 students) out of a class of 20 student teachers in each of the two sessions. In comparing student teachers' entries in the pre-module and post-module questionnaires, Table 5.3 was constructed to show the teaching sequences identified and the total number (n) of responses for each sequence in the sessions. In the last session, a number of students (including the Case-98 students) gave more than one preferred teaching sequence.

Table 5.3
A Comparison between the Pre- and Post-module General Teaching Sequence (GTS) Stated by Student Teachers, Phase II, 1998-99 (N = 15)

Response[a]	Stated teaching sequence	n	%	Response by Case-98[b]		
	Session 1 (28/1/1999) (Pre-module)					
(1)	Introduction-development-consolidation-conclusion	13	87	E1	E2	E3
(2)	Expository method	1	7			
(3)	Discovery method	1	7			
	Session 13 (17/6/1999)[c] (Post-module)					
(1)	Introduction-development-consolidation-conclusion	3	20			
(2)	Expository method	10	67	E1	E2	E3
(3)	Discovery method	10	67	E1	E2	E3

Note. [a]15 returns out of 20. [b]Case-98 consisted of three outstanding student teachers E1, E2 and E3 chosen from Class-98; their responses were also counted in the calculation. [c]A number of students put down more than one preferred teaching sequences (e.g., E1, E2 and E3), but some did not give any, so from the 15 returned questionnaires, a total of 23 responses were obtained.

It can be seen from Table 5.3 that there was a change in the Class-98 students' teaching orientation in this second phase. The same three teaching sequences, namely: (1) a four-stage sequence: Introduction, development, consolidation and conclusion, (2) "expository method", and (3) "discovery method" were recorded; however, Class-98 members seemed to adopt two teaching orientations. More than half (67%) of the respondents were observed to shift explicitly towards the learner-interaction end (which was implied by the stated "discovery method"), and the same percentage (since students gave more than one sequence) to the content-performance end (which was implied by the "expository method") of the teaching continuum. (In the next subsection, I interpreted the four-stage sequence in (1) above as a content-performance orientation, see pages 198-199: "Suggested Teaching Sequence"; see also Chapter Four, pages 127-128, on my interpretation of the sequence.) As for the Case-98 study group, all the three students wrote down that they preferred both the expository and discovery approaches (thus rendering the number of responses n failed to total 100%).

Student teachers' articulation and reflection in their journals may perhaps better inform Class-98 members' teaching orientation and will be discussed next.

Results from Student Teachers' Journals: JWW, 1998-99

Among the several changes in implementing the Phase II study considered earlier, one involved the provision of a particular set of journal writing guidelines for the students (in Appendix 3G, page 328) and another involved the separate collection of student teachers' self-articulation and self-reflection journals (see Chapter Four, pages 179-180: "Journal Writing"; see also Chapter Three, page 102, Table 3.9). The dates of the (two) class sessions in which journals were collected and the main themes were:

- Session 2 (4 February 1999): Teaching of skills (skill teaching)
- Session 5 (11 March 1999): Teaching of principles (principle teaching)

(see Chapter Three, page 106, Table 3.11, and page 110, Table 3.14).

Student teachers' journals were collected during the two class sessions only, because in other sessions either they could not finish writing up their ideas during class or there were other related class activities hindering their journal writing (the details of what had happened in other sessions are reported in Appendix 5A, pages 403-428; see also the schedules of activities in Tables 3.11 and 3.14 of Chapter Three, pages 106 and 110).

Of the two class sessions in which student teachers' journals were collected, the one on Thursday, 4 February 1999 (session 2), was about the teaching of a mathematics skill – namely, solving simultaneous linear equations. Student teachers' journals were collected, firstly, after their initial self-articulation, and then after the whole-class discussion and their own individual self-reflection. Resembling what had been done in Phase I (Chapter Four, page 129), descriptions about their teaching therein were categorised and recorded in Appendices 5G1-5G2 (pages 441-442). The other class session in which student teachers' journals were collected was on 11 March 1999, which was session 5, and the topic dealt with in this session was the verification of an algebraic identity (which I considered a principle in mathematics). Student teachers' journal entries were similarly classified and tabulated in Appendices 5G3-5G4 (pages 441-444).

Students' journals were analysed according to three main themes: (1) the teaching sequence that they intended to use, (2) examples, non-examples and exercises to be employed, (3) the important points they thought they should stress in the teaching process. (See Chapter Four, pages 179-180, for the criteria regarding these key issues.) Student teachers' journal records as regards their intended use of the teaching sequence (i.e., point (1) above) were obtained from Appendices 5G1-5G4 (pages 441-444) and they are displayed in Table 5.4. Analysis of these sequences (and hence the inferred teaching orientation) will be reported in the following subsections: "Suggested Teaching Sequence" (pages 198-201) and "Teaching Orientation Inferred from Teaching Sequences" (pages 201-202). The analysis related to points (2) and (3) above will be reported in later subsections (respectively on page 203: "Use of Examples, Non-examples and Exercises" and page 204: "Important Points to Stress").

Suggested Teaching Sequence

Students' self-articulation, as indicated in the 15 journals (including those of E1, E2 and E3) that were collected in the second class session on 4 February 1998 (Table 5.4), showed that the Phase II students still asserted the four-stage teaching sequence that most of them stated in the first session (as seen in the pre-module GTS questionnaire responses, e.g., Table 5.3, page 196). However, student teachers did not write down clearly whether the activities suggested in their journals were to be conducted by the teacher or by the pupils. Consequently, I found it very difficult to identify student teachers' teaching orientation if I only analysed their journals. Therefore, I interpreted student teachers' beliefs based on their journal entries, together with what they said in the class presentation during these two class sessions. My record of lessons indicated that during the class presentation, the orientation implied by most presenters (and hence the group of student teachers represented by the presenter) inclined towards teacher-centredness. For example, one of my records for session 2 (4 February 1999) was: "Teachers should not dominate the whole lesson" (Appendix 5A, Thursday, 4/2/1999, page 405). I considered this sentence to be indicative of the more performance-focused teaching orientation demonstrated by my students.

Table 5.4
The General Teaching Sequence (GTS) from Student Teachers' Journals, Phase II, 1998-99

Stated method	n	%	Response by Case-98[a]		
Session 2 (4/2/1999) (skill teaching – self-articulation)[b]					
Revision-development-consolidation- conclusion	15	100	E1	E2	E3
Inappropriate/irrelevant teaching method	1	7			
Session 2 (4/2/1999) (skill teaching – self-reflection)[c]					
Revision-development-consolidation- conclusion	15	100	E1	E2	E3
Sandwich[d]	3	20	E1		
Inappropriate/irrelevant teaching method	0	0			
Session 5 (11/3/1999) (principle teaching – self-articulation)[e]					
Discovery	3	20	E1		E3
Expository	12	80			
Sandwich	2	13	E1		
Inappropriate/irrelevant teaching method[f]	5	33			E3
Session 5 (11/3/1999) (principle teaching – self-reflection)[g]					
Discovery	4	27	E1		
Expository	11	73			E3
Sandwich	4	27	E1		
Inappropriate/irrelevant teaching method[h]	2	13			

Note. [a]Case-98 consisted of three outstanding student teachers E1, E2 and E3 chosen from Class-98; their responses were also counted in the calculation. [b]15 returns out of 20. However, since some students gave more than one preferred teaching sequences, but some did not, the total number of responses was 16. [c]See b. [d]This is the cycle teacher talk/pupil activity/teacher talk/pupil activity. [e]15 returns out of 20; E2 was absent. See also b. [f]Required only to verify the identity, but student teachers also proved it. [g]See e. [h]See f.

At the end of this class session (4 February 1999), the journals collected showed "improvement", although slight, in two aspects. First, despite the continual 100% "support" for the four-stage teaching sequence, 20% of the 15 returned journals (with E1's being one of them – indeed, E1 gave two sequences) also espoused the use of the "sandwich" method (Table 5.4), a learner-focused approach which had been introduced by me in the class session (see my interpretation in Chapter Four, pages 130-131). I would interpret this as an awareness of using a more learner-centred approach by some student teachers. The second improvement was that there were no students giving inappropriate and irrelevant teaching sequences in their journals.

In the next set of journals collected from 15 students (excluding E2 who was absent on the day) in the fifth session (11 March 1999), two distinctive features were noted in Table 5.4. First, no students suggested the "four-stage teaching sequence", which almost all had put down in their responses to the GTS questionnaires seen earlier. Second, all were more explicit and lucid in describing the teaching approaches to be used (Appendix 5A, Thursday, 11/3/1999, page 410). However, the majority of student teachers still asserted that the expository approach would be used – this was found in 80% of the returned journals collected at the beginning and 73% collected at the end of the session. Only about 33% stated, at the beginning of the class session, that they would use either the "discovery" or the "sandwich" approach (a pupil-centred approach), and 54% expressed likewise in their journals at the end of this class session (E1 showed his preference for both sequences in the beginning and at the end of the class session). It appeared that, even towards the end of my module, only a half of the student teachers would adopt a more learner-centred or constructivist approach.

As shown in Table 5.4, there were again teaching sequences (produced by two student teachers) classified as "inappropriate/irrelevant teaching method" in this fifth session because the student teachers proved the identity in addition to providing merely concrete numbers to justify the equality (see also explanatory notes f-g in Table 5.4). Though there were only two responses belonging to this category, they gave me the impression that there were student teachers who could not distinguish between verifying an identity and proving it – and E3 was one of them. However, when a teacher had an intention to prove an identity himself or herself, I considered him or her more teacher-focused than pupil-centred, irrespective of the fact that providing a proof was unnecessary in this case.

E2 was absent in this session (five) and no journals were collected from her. E1 displayed the learner-interaction belief in his two journals written in this session; and judging from Table 5.4, E1 was one of the few student teachers who appeared to have changed progressively from the initial content-focused views to the more learner-focused orientation. E3, on the contrary, switched to the use of the expository approach at the end of this session, whereas in the beginning, he stated a preference for the use of discovery. He also illustrated in his journals his understanding of both verifying and proving a formula at the same time.

Teaching Orientation Inferred from Teaching Sequences

Adopting a similar method in presenting student teachers' teaching orientations inferred from their stated teaching sequences in the GTS questionnaires and in their journals in Phase I of my study (Chapter Four, pages 133-134), the teaching sequences stated by the 2SC-98 students are first shown in Tables 5.3 (page 196) and 5.4 (page 199). These were then grouped and consolidated, as in Phase I (Chapter Four, pages 133-134), into either the "content-focused" or the "learner-focused" orientations, and are presented in Table 5.5. Student teachers' asserted sequences in their journals, namely, "introduction/revision-consolidation-conclusion" and "exposition", were categorised as "content-focused" orientations; whereas processes such as "discovery" and "sandwich" were grouped as "learner-focused" orientations.

From Table 5.5, it can be seen that the majority of the 2SC-98 students held the more traditional content-focused beliefs. The learner-interactive orientation, on the other hand, was also becoming better acknowledged by the student teachers – a rise in its frequency of acceptance towards the end of the module can be clearly seen in the table.

Table 5.5
The Teaching Orientation of the 2SC-98 Students Inferred from the General Teaching Sequence (GTS) Questionnaire and Journals (JWW), Phase II (1998-99)

	Percentage response					
	Session					
Teaching orientation	1	2(1)	2(2)	5(1)	5(2)	13
Content-focused	94	100	100	80	73	87
Learner-focused	7	0	20	33	54	67

Note.
There were 15 returns (including E1, E2 and E3) in sessions 1, 2 and 13; there were 15 returns (excluding E2) in session 5.
The numbers 1 and 2 within parenthesis under "session" indicates before discussion and after discussion.
Percentages were obtained from Tables 5.3 and 5.4. However, since some students gave more than one preferred teaching sequences, but some did not give any, the total percentage response may not be 100.
Percentage responses to the two items "introduction/revision-development-consolidation-conclusion" and "exposition" were added and entered against the "content-focused" teaching orientation in this table.
Similarly, percentage responses to the items "discovery" and "sandwich" were added and entered against the "learner-focused" orientation.

The teaching orientations of these student teachers, as interpreted from their suggested teaching sequences recorded in their journals and the GTS questionnaires, and interpreted from their presentation, differed from the implications obtained from the results of the BTM survey. The analysis of the overall BTM results indicated a seemingly invariant socio-constructivist belief (pages 186-187: "2SC-98 Overall Teaching Orientation") that was different from the more traditional belief – constant throughout the second semester – reflected from the qualitative data. The qualitative data, however, signalled a growing acceptance for the interaction approach as the module progressed (see the foregoing paragraph).

Overall, student teachers in the 2SC-98 Class displayed more stable stated beliefs about mathematics teaching than the 2SC-97 Class members, whose teaching disposition changed and fluctuated as they progressed through the module (e.g, see Chapter Four, page 157: "Overall Results (Teaching Beliefs, 1997-98)").

Use of Examples, Non-examples and Exercises

As regards the use of examples and non-examples by the whole class, results are found in Appendices 5G1-5G4 (pages 441-444) and related findings are recorded in Table 5.6. The journals showed that students recognised the importance of using examples in teaching mathematics – teaching mathematics by means of examples is superior to merely giving definitions or by directly transmitting theoretical knowledge to pupils in junior secondary schools. The majority of the student teachers preferred to use more than one example in teaching, with the number of student teachers showing this preference increasing gradually to 100% in the second part of session 5. For the use of non-examples (which are often used in association with examples of a given concept – non-examples are not examples of the given concept), my students appeared to be unaware of their use in session 2, but at the beginning of session 5, 20% noted that non-examples could be used, and the percentage increased to 40% at the end of the meeting. As for the students in the Case-98, they suggested that more examples should be used in teaching (see Appendices 5G1-5G4, pages 441-444).

Table 5.6
Specific Teaching Methods of the 2SC-98 Students Extracted from the Journals (JWW), Phase II (1998-99)

	Percentage response			
	Session			
Teaching method	2(1)	2(2)	5(1)	5(2)
By more than one example	60	60	93	100
By one example	33	7	7	0
By no example	0	13	0	0
By non-examples	0	0	20	40

Note.
There were 15 returns (including E1, E2 and E3) in session 2; there were 15 returns (excluding E2) in session 5.
The numbers 1 and 2 within parentheses under "session" indicates before discussion and after discussion.
Percentages were obtained from Appendices 5G1–5G4.
Sessions 2 was devoted to the teaching of the methods of solving simultaneous linear equations and session 5 to verification of an identity.

Important Points to Stress in Teaching

As shown in their journals, originally, my students did not know what to stress when solving simultaneous equations and in verifying an identity. They merely gave a vague idea, for instance, "revision", "use the substitution method" without giving details about what they should do (see Appendix 5A, Thursday, 4/2/1999, pages 405-406). However, they showed significant improvement later in being able to identify the important teaching points. Evidence could be found in their journal entries; for instance, "the teacher let pupils substitute for a and b into the left side and the right side" – which I think was relevant and clear (Appendix 5A, 11/3/1999, page 410). Similar results were seen in journals produced by the Case-98 students (Appendices 5G1-5G4, pages 441-444).

Thus, I noted a major improvement in the quality of the journals both in terms of clarity and relevance concerning the important points to stress during teaching. In describing a teaching sequence, I would anticipate a lucid and a relevant procedure in teaching a particular topic, including the provision of pupil-pupil and teacher-pupil interactions, of graded examples, non-examples and exercises, and of highlights of common misconceptions and possible remedial measures (e.g., see Appendix 5A, pages 405-406, 410, for my criteria in judging the quality of a journal). Table 5.7 shows the percentage of student teachers, in each session, being able to provide "good" and "satisfactory" indications.

Further study of the Case-98 students' responses in the Phase II implementation period with respect to their teaching orientation and beliefs will be reported and discussed next. Appendices 5H1-5H4 (pages 445-459), 5I1-5I4 (pages 460-472) and 5J1-5J4 (pages 473-489) display respectively the responses by E1, E2 and E3 in the GTS questionnaire, the journal records, the lesson observations and post-lesson discussions, and the results of the end-of-module interviews INT (which can be found in Appendix 3D, page 323).

Table 5.7
The Quality of the Stated Important Points during Teaching by the 2SC-98 Students Extracted from the Journals (JWW), Phase II (1998-99)

	Percentage			
	Session			
Stated important points	2(1)	2(2)	5(1)	5(2)
Good (Clear and relevant)	13	40	87	87
Satisfactory	80	60	7	7

Note.
There were 15 returns (including E1, E2 and E3) in session 2; there were 15 returns (excluding E2) in session 5.
The numbers 1 and 2 within parentheses under "session" indicates before discussion and after discussion.
Percentages were obtained from Appendices 5G1--5G4.
Sessions 2 was devoted to the teaching of the methods of solving simultaneous linear equations and session 5 to verification of an identity.

Case Members' Beliefs About Teaching Mathematics, Phase II, 1998-99

E1

As noted earlier, E1's responses to the BTM survey indicated that he most likely had a social constructivist disposition towards teaching mathematics throughout, since both pre- and post-module scores were high (respectively 3.7 and 3.6, Table 5.1, page 186).

His written responses to the GTS questionnaire, at the start of the module and after it ended, showed that, initially, E1 held a more traditional teaching orientation, but finally, he appeared to have adopted the use of two roughly contrasting teaching sequences – one signified a learner-focused approach and the other the expository approach (pages 199-200: "Suggested Teaching Sequence"). E1, however, claimed to use the latter more often, downplaying the discovery method, which was more in line with a constructivist approach (Appendix 5H1, page 445). And yet a careful study of the activities he provided in the teaching sequences confirmed that even when he chose the expository approach, he planned many activities for his pupils. These activities could facilitate knowledge construction, and so there was some evidence that E1 also possessed a learner-focused teaching orientation – though probably not strongly.

He mentioned several times that he wanted his pupils to understand and not to learn by rote mathematics theories. He claimed that he would be flexible in his teaching; he would encourage pupils to attempt solving problems rather than giving direct answers to them; and he would develop in pupils a positive attitude to mathematics learning.

However, he said that the teaching practice altered his views about the use of the discovery method. He remarked that the method depended on the standard of the pupils. The following quote illustrates this point:

> The pupils are not willing to discover the mathematics. If you prepare some activities, there will be discipline problems and so you have to look at the standards of the pupils in order to decide on the teaching methods. (Appendix 5H4, pages 458-459)

This could be the reason for his response in the post-module GTS questionnaire that he had two preferred teaching sequences and that he gave more emphasis to exposition than discovery (see the foregoing paragraphs, page 205).

The teaching practice also enabled E1 to recognise his inadequacies and inexperience in school teaching:

> I used to think it easy but now I think it's difficult....We know how to do it (solve a problem) but we don't know how to teach them. (Appendix 5H4, page 459)

> I am not as good as you (in teaching experience). (Appendix 5H4, page 459)

E1 reflected on his inadequacies in teaching and in teaching experiences, and he constructed the belief that pupils should read the text first before coming to class:

> I think I will ask the pupils to prepare the lessons by themselves before they come to the class so that they will understand what is going on. (Appendix 5H4, page 459)

In his actual teaching performance observed by me during the field experience, E1 used very few examples and no non-examples despite his claim that he could give examples rather than defining the concepts:

> I think I do not need to give the definitions of the concepts, but I can give examples instead….But I didn't do that. (Appendix 5H3, page 452)

He admitted that he considered concept teaching very simple (Appendices 5A, Tuesday, 20/4/1999, page 416; 5H3, page 454), and yet he did not know the concepts to be taught very well (Appendices 5A, Tuesday, 20/4/1999, page 416; 5H3, page 452); finding daily life examples was difficult (Appendices 5A, Tuesday, 20/4/1999, page 416; 5H3, page 454). Neither did he articulate the important points sufficiently in his teaching (Appendix 5H3, page 452). One point that may be worth noting is that when I discussed his teaching performance, I also observed that he could not use appropriate terminology – for instance, ELPS and "sandwich" approach – to label the teaching activities that he was using (Appendix 5A, Tuesday, 20/4/1999, page 416).

In summary, from his responses to the questionnaires, his journal records and my observation of his teaching, I can say that E1 showed an inclination towards teaching the learner-interaction end of the teaching continuum at the conclusion of the study.

E2

Judging from E2's responses to the BTM pre- and post-module survey (both mean agreement scores were roughly 3.5 with a standard deviation about 1, Table 5.1, page 186), I could speculate that E2 believed in a learner-focused approach to teaching and had not changed her beliefs at the end of the methodology module.

However, the results displayed in Tables 5.3 (page 196) and 5.4 (page 199), regarding the general teaching sequence E2 asserted in the GTS questionnaires and in her journals, indicated that on the surface, E2 possessed a content-focused orientation, rather contrary to the quantitative results obtained in the BTM survey. Initially, she presented what I considered a teacher-centred four-stage teaching sequence "introduction-development-consolidation-conclusion" in responding to the pre-module GTS questionnaire in the first session (Appendix 5I1, 28 January 1999, page 460) and in the journals dated 4 February 1999 (Appendix 5I2, second session, page 461). She showed that she could clearly articulate what she would like to do in these fictitious lessons.

At the end of the module, E2 gave an expository sequence in the GTS survey supplemented with a "sandwich" approach (Appendix 5I1, last session, 17 June 1999, page 460) – exhibiting what I consider a pupil-centred constructivist orientation. She explained that the use of exposition was the result of the crammed teaching syllabus in the school.

The observation of E2's teaching practice and follow-up discussion (Appendix 5I3, pages 465-469), together with the end-of-module interview (INT) (Appendix 5I4, pages 470-472), revealed E2's content-performance disposition towards teaching mathematics in addition to her learner-focused beliefs.

In her actual teaching, E2 used direct instruction that was mingled with challenges and pupil activities in the form of class exercises (Appendix 5I3, pages 465; Appendix 5A, Tuesday, 27/4/1999, page 417). E2's statements in the post-lesson discussion revealed her performance-focused beliefs:

> I have to write everything on the blackboard and let them know. (Appendix 5I3, page 467)

> I think after pupils learn the method of proof, then understanding will follow. (Appendix 5I3, page 468)

The last assertion reflects E2's belief that understanding comes after the actual mastery of procedures.

In the INT (Appendix 5I4, page 470), E2 emphasised both questioning and pupil explanation as a means to help to develop thinking ability and learning attitude. However, E2 expressed her expectation that pupils listen to the teacher's exposition, because she did it when she was a secondary student:

> It's different from learning the subject of Chinese, which you can learn at home all by yourself, but for maths...I have to attend the class and listen to what my teacher said in the lesson. (Appendix 5I4, page 470)

She went on to affirm her role:

> I will keep on explaining, but in small steps....If I can transmit it clearly, they will follow....I don't want to talk too much....I usually do the talking....I used to think if I can make myself clear in my teaching, then it's OK. (Appendix 5I4, page 470)

Another aspect of pupils' performance that would satisfy E2 was recitation of what she taught in class:

> They will recite what they learnt but I am still very happy. (Appendix 5I4, page 471)

It seems that E2 had not changed her belief that reciting and memorising were important for learning mathematics. She declared that she had not been affected by the teaching practice, though she frequently mentioned, in the interview, the school mathematics teacher's behaviour in class teaching (Appendix 5I4, pages 470, 471, 472; Appendix 5A, Monday, 28/6/1999, page 427; see also Tuesday, 27/4/1999, page 417). She then expressed her interest in teaching, and acknowledged that the teacher played a very crucial role in teaching:

> Of course, good teaching depends on the teacher – the teachers' knowledge about pupils' capability and the amount of effort the teachers would like to spend. (Appendix 5I4, page 471)

Overall, I would consider E2 a keen teacher possessing a content-performance orientation to teaching mathematics. She had shown improvement in both articulating the important points in her journals (Appendix 5I2, page 461) and in her teaching performance (Appendix 5A, Tuesday, 27/4/1999, page 417) – some of the activities she used in her teaching, to a certain extent, could provide opportunities for her pupils to construct knowledge actively.

E3

When compared to E1 and E2 (and with the Class-98 students), E3 gave slightly lower mean agreement scores to the BTM survey before and after the methodology class (3.5 and then 3.3, see Table 5.1, page 186). This implied that E3 initially possessed a constructivist inclination and later shifted to a position intermediate between the learner-focused and the teacher-centred approach in the teaching continuum.

The performance-focused orientation was particularly notable in the sequences articulated by E3 in the GTS questionnaires and in the journals (respectively Appendices 5J1 and 5J2, pages 473 and 474-478; see also Tables 5.3 and 5.4, pages 196 and 199). In the initial GTS questionnaire, the stated sequence was an expository one with "pupils listen by keeping silent" (Appendix 5J1, page 473). The subsequent teaching sequences presented were both an exposition and a discovery, with the latter claimed to be less frequently used. E3's journals also indicated a teacher-dominated approach throughout, with the exception of initially suggesting a discovery approach on Thursday, 11 March 1999, only to later change back to a direct instruction on the same day after self-reflection (Appendix 5J2, pages 474-477).

Beliefs in direct teaching were also shown in E3's teaching and in the after-lesson discussion (Appendix 5J3, pages 479-486). In the lesson observed on Monday, 19 April 1999, E3 used exposition in class coupled with a "sandwich" approach. In the post-lesson discussion, E3 commented:

> I am telling them that we are drawing these lines in order to solve the problem. (Appendix 5J3, pages 480-481)

> Actually I have asked pupils if there are any other ways to solve the problem, but they gave no response, and then I simply went on teaching. Actually I want to teach this construction and tell my pupils that this line is a vertical line and you don't need to learn Pythagoras' Theorem in solving them. (Appendix 5J3, page 484)

> I want to teach them step by step on how to do it because they have not learnt it before. (Appendix 5J3, page 483)

However, E3 also displayed a learner-focused orientation:

> I have taught them and want to revise with them. (Appendix 5J3, page 480)

> I will teach them about the areas and then I will guide the pupils to get the answers. (Appendix 5J3, page 483)

and,

> I think the revision exercise is very interesting and so we did the problem together. (Appendix 5J3, page 481)

The learner-focused belief was further justified in the interview about teaching mathematics (INT) conducted at the end of the module (Appendix 5J4, pages 487-489). E3's assertions in a number of places during the interview seemingly pointed to the social constructivist belief about teaching. For instance, he claimed that the teachers' role was to help the whole class or individual pupils, depending on the situation, in solving problems, to enhance communication and to voice their own needs and difficulties in learning (page 487). When pupils could not solve any problem, E3 would check his pupils' mathematics foundation and would revise previous work and supplement it with daily life examples (page 488).

Nevertheless, it cannot be denied that E3 would focus on content-performance rather than learner-interaction. He confirmed that he used considerable demonstrations in his teaching, especially in teaching concepts that were supported by many examples and by, where necessary, pictures (Appendix 5J4, page 488). He believed that success in solving a problem indicated understanding and that pupils' explanations were not necessarily an indicator of understanding:

> I think some of the pupils cannot explain themselves. I mean they know how to do a task but they don't know how to express their thoughts...Does it mean that they are poor in mathematics? No, it's just the power of expression. (Appendix 5J4, page 488)

> I think solving is more important because if they can solve the problems, this means they know the meaning behind it, and explaining why is not so important. (Appendix 5J4, page 488)

> As pupils, they don't really need to explain it (the procedure). (Appendix 5J4, page 488)

E3 was puzzled at his own teaching, however. Before the teaching practice, he thought teaching mathematics was simple and easy, but later, he had a different view:

> Completely different. Before the TP, I think it's easy...but now it's different....Every pupil has his/her own learning style. This means my teaching style may not be suitable for all pupils and I have to think of other ways....I tried very hard to explain the procedures to pupils but they still didn't understand....Sometimes knowing a topic myself doesn't mean that others can accept what I am conveying. (Appendix 5J4, page 489)

This assertion, though resembling E1's statement as seen earlier (page 207), led to a resolution in E3's future teaching that was different from E1's constructed method. E3 decided to try to find more examples and teaching materials, which was unlike E1, who asked pupils to prepare their lessons beforehand (pages 207-208). In his journals (e.g., the one dated 11/3/1999 in Appendix 5J2, page 477), E3 stated that he would like to use more examples in his teaching; nevertheless, he claimed that when he was a pupil, he never needed many examples in learning mathematics. He further declared that he had a definite requirement for professional development and lifelong learning (Appendix 5J4, page 489).

Skill teaching appeared to be particularly significant for E3, because the mastery of procedures was advocated in many places in his teaching journals, discussion and interview, and was also displayed in his real classroom teaching that I observed on Monday, 19 April 1999 (e.g., Appendix 5J2, pages 475, 477; Appendix 5J3, pages 418, 482, 485; Appendix 5J4, pages 488, 489). Activities that facilitated the teaching of principles were also preferred – this was probably illustrated in his self-reflection dated Thursday, 11 March 1999 (Appendix 5J2, page 477), where he showed that he could distinguish between verifying and proving. He also anticipated the need to prepare many examples to be used in verifying the algebraic identity.

However, detailed teaching points had not been elaborated and displayed in his lesson plans during the field experience – indicating either that E3 was still inexperienced in his teaching (Appendix 5A, Monday, 19/4/1999, page 415) or that he did not bother to express detailed written descriptions about his teaching (although he did it rather well in his journals dated 11/3/1999 in Appendix 5J2, pages 476-477). A few lines extracted from the after-lesson discussion (in Appendix 5J3) illustrate my point:

> Me: You don't have those here in the lesson plan...
>
> E3: I simply tick the work in the textbook.
>
> Me: I can see you don't have enough exercises for pupils.
>
> E3: You cannot see from the lesson plans....
>
> Me: I think you should add the questions that you would like to ask your pupils...
>
> E3: ...Is it true that I am not allowed to read the lesson plans while I am teaching during the lesson?...(Appendix 5J3, pages 480-481)

Overall, E3 showed his zeal for mathematics teaching in his craving for further professional learning. He demonstrated a non-constructivist approach displaying a content-performance focus. However, in the final interview, E3 seemed to have changed his traditional beliefs about teaching mathematics to a more learner-focused inclination. He was apparently still in the process of searching for an orientation to teaching that he considered would be suitable for both himself and his pupils.

Summary (Case Members' Beliefs, 1998-99)

The Case-98 students seemed to believe in, and use, the direct teaching approach, but they were also aware of the need to provide more opportunities for pupils to do their own work – the procedures of teaching took the form of a "sandwich" approach (though the name of the approach could not be identified by members of the Case-98) (e.g., see pages 206, 207 for E1; page 209 for E2; page 212 for E3; page 417, Appendix 5A, Tuesday, 27/4/1999, "Overall Observation"). This teaching behaviour could show a content-performance focus, but embedded in it were constructivist beliefs that might not necessarily be construction – rather based on discourse.

Important points in teaching have been noted in most of the Case-98 students' journals, and improvement in the elaboration of teaching points has been demonstrated (e.g., see Appendix 5I2, pages 461-462, for E2; Appendix 5J2, pages 474-477, for E3). In the actual teaching, the stated preferred specific methods of teaching have also been used (see Appendix 5A, Tuesday, 27/4/1999, page 417: "Overall Observation"). Examples had been planned, but the use of non-examples was rare (see Appendix 5A, Tuesday, 27/4/1999, page 417: "Overall Observation"). Furthermore, the use of discussion, for instance, was seemingly not yet acceptable to the three outstanding students, whose teaching beliefs may possibly still be influenced by their previous schooling (as in the case of E1, page 206; of E2, page 210; and of E3, page 214) and by the mentors in the field experience (e.g., my perception of E2's teaching beliefs, pages 210-211).

Overall Results (Teaching Beliefs, 1998-99)

This subsection summarises the evidence obtained from the various data collection methods with respect to the 2SC-98 (and 2SC-97) student beliefs about teaching mathematics at the end of the methodology module:

Class-98 Outcomes

- The standard deviations in the scores for the BTM questionnaires (both pre- and post-module) indicated that the 2SC-98 students possessed a variety of beliefs about teaching mathematics (which resembled the results obtained in Phase I) (pages 194-195: "Summary (BTM Results, 1998-

99)"; Chapter Four, page 157: "Overall Results (Teaching Beliefs, 1997-98)").

- In particular, the 2SC-98 students collectively displayed stable learner-focused orientations when the BTM scores were analysed (whereas the Phase I results indicated unstable overall beliefs) (page 194: "Summary (BTM Results, 1998-99)"; Chapter Four, page 157: "Overall Results (Teaching Beliefs, 1997-98)").
- Students in the Class-98 displayed unchanged traditional teaching orientations, as implied by the results of the analysis of the responses to the GTS questionnaires and the journals. Yet there was a growing acceptance for the more learner-focused teaching approaches too (pages 201-202: "Teaching Orientation Inferred from Teaching Sequences"). (In Phase I, the 2SC-97 students swung between both ends of the teaching continuum, but seemingly adopted the traditional approach at the conclusion of the module; see Chapter Four, page 157: "Overall Results (Teaching Beliefs, 1997-98)"). These two opposed beliefs were indicative of unstable beliefs inherent among the student teachers.
- The categorised BTM results indicated that student teachers held unchanged beliefs in the following (parallel to the results found in Phase I): (1) the role of a mathematics teacher as a facilitator of learning, and (2) persistent questioning could alter pupil knowledge about mathematics. (pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, pages 157-158: "Overall Results (Teaching Beliefs, 1997-98)").
- The BTM results signalled an unchanged uncertainty as to the benefits of group interaction in mathematics learning. (In Phase I, student teachers concurred on the advantages of the group dynamics in learning.) (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 158: "Overall Results (Teaching Beliefs, 1997-98)".)
- Regarding the employment of the expository approach in teaching, the 2SC-98 students did not demonstrate any particular stance (as reflected from the categorised BTM results): They were undecided throughout the module (pages 194-195: "Summary (BTM Results, 1998-99)").

Alternatively, the students apparently had two teaching approaches (with two different perspectives) for use (as reflected from the analysis of the GTS and the journals, see the foregoing result stated in this subsection, page 217). (The Phase I students, however, showed that they finally chose the direct instruction approach; see Chapter Four, pages 157-158: "Overall Results (Teaching Beliefs, 1997-98)".)

- Student teachers could not decide whether their pupils possessed alternative mathematics knowledge and remained undecided on this matter at the conclusion of the module (BTM results). They could not decide if it was worthwhile to accept the idiosyncratic ideas brought to the class by their pupils and to allow them to justify their explanations. (These beliefs were different from those of the 2SC-97 students – they also remained undecided if it was beneficial to acknowledge pupils' different held perspectives, but they maintained their belief that they should allow their pupils to attempt to justify their explanations). (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 158: "Overall Results (Teaching Beliefs, 1997-98)".)
- When teaching problem solving, the 2SC-98 students maintained their stance regarding the need to provide clear and concise solutions to their pupils. (The 2SC-97 students, however, became unsure if such an act was beneficial to learning.) (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 156: "Overall Results (Teaching Beliefs, 1997-98)".)
- The 2SC-98 students, like their peers in the 1997-98, remained undecided as to the content, the amount and the order of mathematics contents to be taught (BTM results). (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 158: "Overall Results (Teaching Beliefs, 1997-98)".)
- The two cohorts of students displayed similar indecision regarding the belief that mathematics problems can be solved without using rules. (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, pages 158-159: "Overall Results (Teaching Beliefs, 1997-98)".)

- The Phase II students still believed that learning of mathematics requires no memorisation; the Phase I cohort remained undecided. (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, pages 158-159: "Overall Results (Teaching Beliefs, 1997-98)".)
- Regarding the belief that mathematics is made up of related topics, while the Phase I students were still undecided, the Phase II students altered their belief from "agree" to "undecided" (shown in the BTM results). (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, pages 158-159: "Overall Results (Teaching Beliefs, 1997-98)".)
- Student teachers continued to believe that they had to understand and enjoy mathematics (parallel to the findings from the BTM surveys in Phase I). (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 159: "Overall Results (Teaching Beliefs, 1997-98)".)
- Student teachers agreed that they could develop an attitude of inquiry while they were accumulating teaching experience (unlike the indecisive attitude displayed by the Phase I cohort in the BTM results). (See pages 194-195: "Summary (BTM Results, 1998-99)"; Chapter Four, page 159: "Overall Results (Teaching Beliefs, 1997-98)".)
- Beliefs changed in student teachers' journals in (1) elaborating the teaching sequences, (2) the use of more examples in planning teaching, and (3) stating clearly the important points to stress in the simulated teaching (page 204: "Important Point to Stress in Teaching"). These changes could not be found in the 2SC-97 journals (see Chapter Four, pages 179-180: "Journal Writing").

Case-98 Outcomes

- In Case-98 students' teaching practice, I could observe an awareness of a detailed elaboration of the teaching sequences and important points and the use of examples. However, there was still a paucity of the employment of class and group discussions and non-examples in teaching. (See page 216: "Summary (Case Members' Beliefs, 1998-99)").

- The 2SC-98 Case students (except perhaps E1, who showed signs of constructivist perspectives) were generally more content-focused than the whole class (see the summary at the end of each subsection "E1", "E2" and "E3" on pages 208, 211 and 215-216 respectively, and a foregoing result on page 217 regarding the Class-98 students' growing acceptance of more learner-focused approaches). (These findings resembled the results obtained in Phase I, see page 159: "Case-97 Outcomes").
- Regarding the effect of teaching practice in altering the Case-98 students' beliefs, findings were unequivocal (pages 205-216: "Case Members' Beliefs About Teaching Mathematics, Phase II, 1998-99"). (1) The idea that teaching was an easy task was changed by E1 and E3 (respectively pages 208 and 214); (2) E1 and E2 found their lack of teaching experience was an obstacle to teaching (respectively pages 207 and 210-211); (3) their secondary school experiences were perceived to have an effect on both E1, E2 and E3's teaching orientation (respectively pages 206, 210, 214); (4) the pupils in the practising school affected the teaching approaches employed by E1 and E3 (respectively pages 207-208 and 214); (5) the school teachers (the mentors) also affected E2's choice of teaching methods (pages 210-211). (Findings were similar to those in Phase I, except (1) and (3) above – these findings were absent in Phase I, see pages 159-160: "Case-97 Outcomes").

The next section reports the constructivist learning environment perceived by my students in the second phase of implementation.

PHASE II – THE CONSTRUCTIVIST LEARNING ENVIRONMENT

Data related to the second-phase constructivist learning environment created in my methodology class was again generated from multiple methods employed with the 2SC-98 cohort of student teachers (the timeline for data collection can be found in Chapter Three, page 110, Table 3.14). The instruments were the end-of-module Constructivist Learning Environment (CLE) survey (which can be found in Appendix 3F, pages 325-327), my students' (including the Case-98 students) descriptions of the methodology classroom in their journals (JWW; the guidelines can be found in Appendix 3B, page 319) and the post-module interview (the interview schedule can be found in Appendix 3D, page 323).

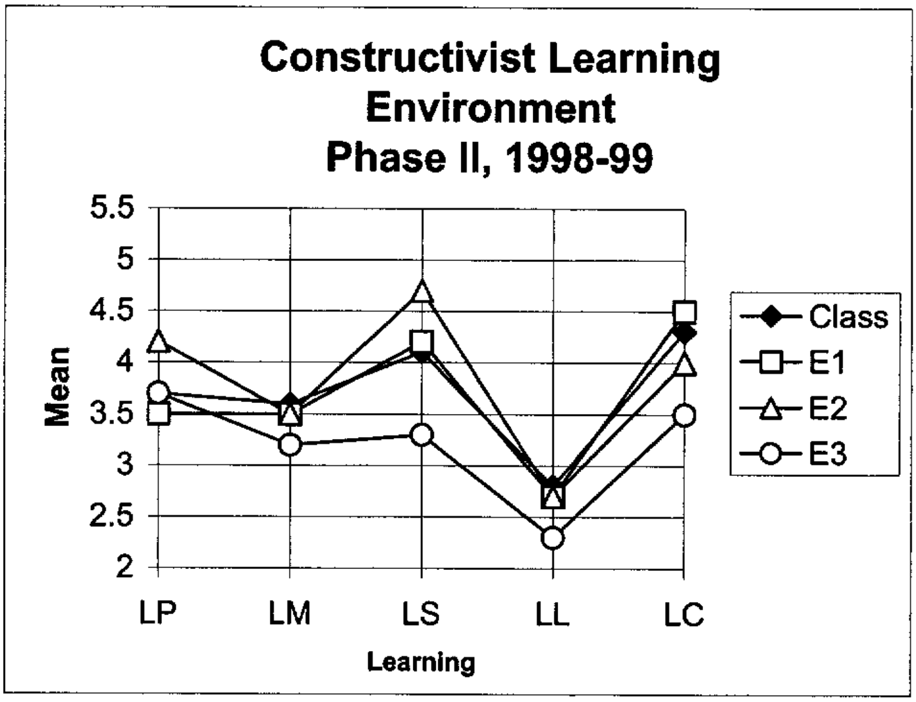
My students' data is analysed and discussed in the pages following.

Results from the CLE Survey (17 June 1999)

The CLE survey (Appendix 3F, pages 325-327) was administered in the last class meeting (17 June 1999) in semester 2, 1999-2000 (see implementation schedule in Table 3.14 in Chapter Three, page 110). Students responded to six CLE items in each of the five categories on a 5-point frequency scale: with "1" indicating "almost never" and "5" for almost always". There were 15 returns out of a class of 20 student teachers (including E1, E2 and E3); scores for each category of items were averaged. Appendix 5K (page 490) and the corresponding graphical representation (Figure 5.1) shows the distribution of the mean frequency scores for the five categories of learning: Learning about pupils' learning (LP), learning about methodology (LM), learning to speak out (LS), learning to learn (LL) and learning to communicate (LC) found from Class-98 and Case-98 members' responses.

Class-98 members' responses to the learning environment that I created were, in general, positive. The average frequency was about 4 for scores of four categories of learning, with the exception of the category of LL (learning to learn) in which the score was only 2.8. Thus, according to my students, there were often opportunities for them to learn to communicate with themselves (LC) (the highest score of 4.3 among the five scores); to learn to speak out and air their views about learning (LS) (the next highest score of 4.1); and to learn about their future pupils (LP) and about the method of teaching (LM) (3.7 and 3.6 respectively). The category "learning to learn (LL)" has the lowest score, probably because, as in Phase I, the type of assessment tasks and the syllabus of this methodology module were all predetermined, and I could not offer more opportunities for student teachers to control their own progress (see also Chapter Four, pages 162-163).

Figure 5.1
The Mean Frequency Scores for the Social Constructivist Learning Environment (CLE) With Respect to the Five Categories of Learning at the End of the Methodology Module (17 June 1999) – Responses by a Class of 15 Student Teachers out of 20, Phase II, 1998-99



The five categories of learning:

- LP = learning about pupils' learning
- LM = learning about methodology
- LS = learning to speak out
- LL = learning to learn
- LC = learning to communicate.

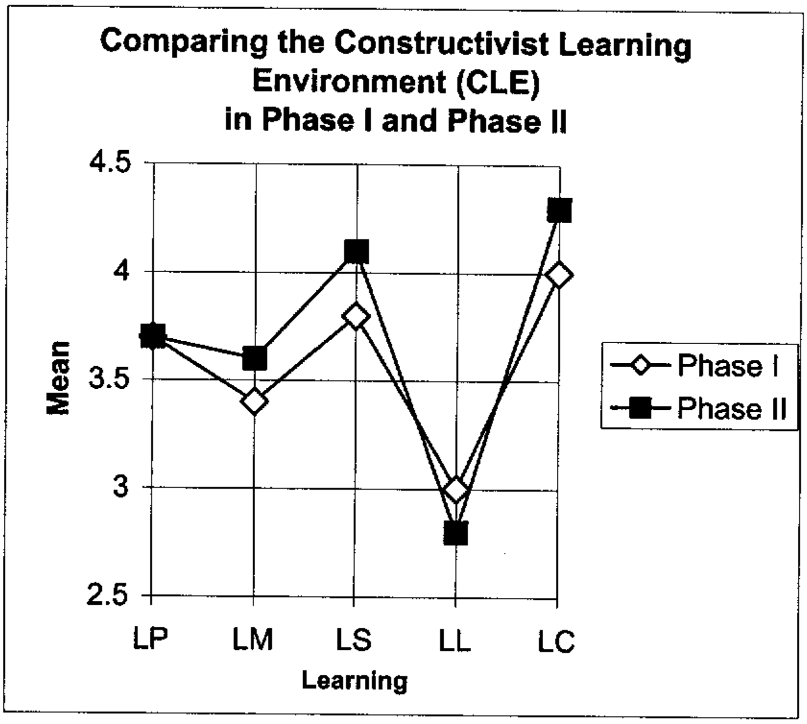
Figure 5.1 shows a similar trend of response by the Case-98 trainees and by the whole class of student teachers. (E3's responses, though positioned lowest in the graph, still run parallel to the other broken lines and will be discussed in the following subsection "Results from 2SC-98 Students' Journals, JWW").

The lowest points all cluster at LL, indicating that there were seemingly few opportunities for student teachers – concurred by students of the Case-98 – to learn to learn. The highest points are again at LS and LC, which shows that there were abundant chances for my students to learn to speak up for their rights and to communicate with themselves. The Case-98 students' relatively low responses to the LP and LM categories of learning imply that I should rethink about my teaching. In other words, I still need to make improvement in assisting student teachers in learning about their pupils' learning and about the teaching methodologies to be used.

The Class-98 students' frequency scores for the CLE Surveys in the two phases of my study are compared in Appendix 5L (page 491) and shown graphically in Figure 5.2 – I considered that an increase in the scores in the second phase could indicate an improvement in the (constructivist) learning environment in my methodology class. The graph shows that there was a slight improvement in Phase II in providing opportunities for learning about methodologies (LM), for student teachers to speak out (LS) and to communicate (LC). There was no change in the scores for learning about pupils' learning (LP), but the scores for learning to learn (LL) were decreased in Phase II.

Overall, in the second phase, there was seemingly an improvement in the constructivist learning environment in relation to promoting social interaction, although this was already considered satisfactory by my students in the first phase (see, e.g., Chapter Four, page 170: "Results from Case-97 Members' Post-teaching Discussions and Interviews"). However, as mentioned in the previous paragraphs, I need to explore how I can improve the three aspects of learning, LP, LM and LL, in future.

Figure 5.2
A Comparison between the Two Classes of Students' Mean Frequency Scores of the Constructivist Learning Environment (CLE) Survey in Phase I, 1997-98 and in Phase II, 1998-99



The five categories of learning:

- LP = learning about pupils' learning
- LM = learning about methodology
- LS = learning to speak out
- LL = learning to learn
- LC = learning to communicate

Results from 2SC-98 Students' Journals, JWW

Student teachers' written descriptions about the classroom learning environment were collected on 20 May 1999 (which was session 9; see Chapter Three, Table 3.14, page 110). There were 13 returns (including journal records of E1, E2 and E3) and their responses were, using the same method used in Phase I (Chapter Four, page 163), classified into seven categories – namely, (1) journal writing, (2) small-group discussion, (3) presentation of group's ideas, (4) whole-class discussion, (5) lecturer intervention during group discussion, (6) lecturer input during class discussion and (7) others. Appendix 5M (pages 492-493) records the frequency responses to each item under each category. However, the seven categories of responses shown in the appendix will be summarised and discussed in the following under the headings (1) journal writing, (2) discussions and (3) the lecturer's teaching methods.

Journal Writing

Out of the thirteen returns, ten (77%) (including E1, E2 and E3) considered journal writing good for learning and two (15%) considered that its results were only satisfactory (Category 1 in Appendix 5M, page 492). In their journals, the Case-98 students expressed the view that self-articulation and reflection allowed them to see their inadequacies in their teaching, but E3 remarked that the process allowed them to air their own opinions about teaching. The following examples from their journals illustrate these points:

> It is good to ask us to reflect about our teaching because I can find out my weaknesses. (E1's remark in his journal dated Thursday, 20/5/1999, Appendix 5H2, page 450)

> In writing journals, reflections, and teaching ideas, I can find out more about my problems in the area of teaching. (E2's remarks in her journal dated Thursday, 20/5/1999, Appendix 5I2, page 464).

> Writing a journal is a very effective way to learning. It not only lets us understand clearly what is insufficient in our own teaching points, but it also allows us to air our opinions about the teaching methodology. (E3's remark in his journal dated Thursday, 20/5/1999, Appendix 5J2, page 478)

Category 1 in Appendix 5M (page 492) shows that there was a student teacher (other than the Case-98 students) who approved the use of journals as a means of letting the lecturer know what the student teachers were thinking, but it also shows that E2, on the other hand, considered that there was too much to write about in a class session.

In comparing student teachers' comments about the methodology classroom environment in the two phases of my study recorded in Category 1 of Appendix 4K (page 399) and Appendix 5M (page 492), I found that the expressions, for instance, "difficult to write", "should give guidance", "cannot finish", which were noted in Phase I, were no longer present in the Phase II journals. Apparently, the 2SC-98 students did not have any difficulties in finishing the journals when guidance had been explicitly provided in their worksheet and when more time was given them for self-articulation and self-reflection in the second-phase class meetings (e.g., see Chapter Four, pages 179-180: "Journal Writing"). Relevant guidance and sufficient time are two crucial factors for my proposed successful future methodology teaching.

Discussions

Responses to the two categories of discussions – small-group and whole-class – were positive, as reflected in Appendix 5M (page 492). All respondents (100%) acknowledged small-group discussions as a means of student teachers' learning from one another (77%, Category 2 in Appendix 5M, page 492) in a lively atmosphere (8%, Category 2 in Appendix 5M, page 492). Both E2 and E3 commented on their own learning in their journals:

> In group discussion, I discover that what I am thinking is rather defective. But our views about teaching complement one another's viewpoints. (E2's remark in her journal dated Thursday, 20/5/1999, Appendix 5I2, page 464)

> We can share and communicate with one another in group discussion. (E3's remark in his journal dated Thursday, 20/5/1999, Appendix 5J2, page 478)

E1's journal entry about the learning atmosphere in small-group discussions was as follows:

> Small-group discussions are excellent because we can be more active in the lectures. The learning environment is warm and enthusiastic, and discussion is lively. (E1's remark in his journal dated Thursday, 20/5/1999, Appendix 5H2, page 450)

As regards the change in the members of groups in different meetings (Category 2 in Appendix 4K, page 399), no comments were noted in the second phase (Category 2 in Appendix 5M, page 492). The 2SC-98 students probably felt at ease with their friends by remaining in the same group throughout all the methodology meetings.

From Categories 3 and 4 in Appendix 5M (page 429), it can be seen that class discussion was also well-received by the 2SC-98 students (but about 20% of the respondents, which included E3, only considered it satisfactory), but group presentation was less favoured (only 54% and again with the exception of E3). There were nine (69%) respondents who commended the class discussion because they could possibly learn from one another (62%) and because the atmosphere was lively (15%); only one student teacher (8%) expressed the view that time was insufficient for discussion (Category 7 in Appendix 5M, page 493). Thus, "whole class discussing the same topic could facilitate learning", although mentioned by a small percentage (8%, Category 4 in Appendix 5M, page 492) of the respondents, still gave me the impression that changes effected in the second phase in this respect had been appropriate.

Both E1 and E2 also commended class discussion and presentation as a means for learning in their journals, and in particular, they said that it could improve their confidence and ability to express themselves:

> I like also group presentation. It is excellent to have a chance to talk to the class. We can also come across and learn different ideas about teaching and thus we can find the best method. (E1's remark in his journal dated, Thursday, 20/5/1999, Appendix 5H2, page 450)

> It is marvellous to have students report their discussion results and teaching methods. We can remind one another of any inadequacies in our plans for teaching, and so we can then be clearer about our own problems. Presentation also increases our confidence in classroom management. (E2's remark in her journal dated Thursday, 20/5/1999, Appendix 5I2, page 464)

As seen previously in this subsection (page 227), E3 did not have a high regard for learning by class discussion and presentation. He wrote:

> Individual presentation of teaching strategies, though it enables us to share our thoughts, makes those who need not present in that particular meeting lazy, and the degree of their participation reduces tremendously. Furthermore, whole-class discussion neglects individual students' needs. (E3's remark in his journal dated Thursday, 20/5/1999, Appendix 5J2, page 478)

E3's foregoing reasons for finding discussion and group presentation only "satisfactory" could possibly also explain his comparatively lower scores in responding to the CLE survey, particularly the very low scores for the categories of LM, LS and LC, not to mention LL (see, e.g., Figure 5.1, page 222). Apparently, he expected me to organise activities other than class discussion to help him to learn the relevant viewpoints in mathematics teaching (LM), to speak out for his own rights (LS), to develop the confidence to communicate with others (LC) and to assist me in planning for his own learning (LL).

In brief, Case-98 members' responses to the learning environment could be considered positive. They found journal writing and class and group discussion helpful in learning. These echoed the positive findings in the CLE surveys in general (pages 221-224: "Results from the CLE Survey (17 June 1999)"). When response rates of the two phases were compared in Appendix 4K (page 399) and Appendix 5M (page 492), the Phase II "scores" were an improvement on those of the Phase I in this respect, thus indicating an improvement in organising a constructivist learning environment.

Lecturer's Teaching

The Phase II students also maintained that the lecturer's intervention during both the group discussion and the class presentation was of a good quality (over 60% responded as shown in Category 5 and Category 6 in Appendix 5M, page 492). In the same two categories, there were favourable responses to providing a wide variety of ideas (15%), convincing ideas (15%), expert ideas (31%), to focusing on the main teaching points (23%) and to the clear expression of these views about teaching (54%). Other positive descriptions from the Case-98 trainees' journals are quoted below:

> It is also good that the lecturer can have his input because his unique teaching ideas often let us learn quite a lot. (E1's remark in his journal dated Thursday, 20/5/1999, Appendix 5H2, page 450)
>
> The lecturer's input can provide more accurate answers to teaching a particular topic, thus enabling students to obtain real expert ideas. (E3's remark in his journal dated Thursday, 20/5/1999, Appendix 5J2, page 478)
>
> The lecturer's final remark (conclusion) on each of our presentations reminds us to look more clearly at our own assignment. (E2's remark in her journal dated Thursday, 20/5/1999, Appendix 5I2, page 464)

> Our lecturer is lively in his teaching, using a lot more examples for illustration. (E3's remark in his journal dated Thursday, 20/5/1999, Appendix 5J2, page 478)

> The lecturer's lively use of the teaching method (the "sandwich" approach) allows us to know and learn the importance of this method. (E2's remark in her journal dated Thursday, 20/5/1999, Appendix 5I2, page 464)

It seems therefore that learning could be facilitated by the lecturer clarifying and, whenever possible, modelling the teaching methods. My effort in providing more systematic input in the second phase had apparently been well received by students (although this might imply that student teachers would prefer more guidance from the lecturer). However, a comment from E1 in the Case-98 study group still suggested that further improvement was required in my input:

> However, the lecturer is unable to highlight the most important points in the lecture content. (E1's remark in his journal dated Thursday, 20/5/1999, Appendix 5H2, page 450)

Data generated from the interviews with the Case-98 students for cross checking my findings will now be discussed. (The interview schedule INT can be found in Appendix 3D, page 323.)

Results from Case-98 Members' Interviews

My 2SC-98 students have probably learnt something about their pupils in their teaching practice, but it is possible that they were not aware of this at all. For instance, E1 responded in the interview (INT) regarding his belief change after the teaching practice:

> I think your theories are OK and I am not afraid. But in reality it's not the case. (Appendix 5H4, page 458)

What E1 meant was that the various methods learnt in my methodology class, though feasible, could not be applied in the actual classroom situation. Perhaps, to an inexperienced teacher, it was difficult to apply these methods, as E1 further commented:

> We don't know how to teach them. (Appendix 5H4, page 459)

E3 also had a same feeling (Appendix 5J4, page 489).

Of course, I should not attribute this inability to apply, during teaching practice, the teaching methods learnt in the methodology class solely to the student teachers' inexperience. Their instruction in the teaching methods may have been inadequate, because, as noted previously (pages 229-230: "Lecturer's Teaching"), E1 commented in his journals that I did not focus on the main points of my teaching in the class meetings.

It is probable that too many different teaching methods were introduced to my students in the methodology module. E2 remarked during the interview (INT) that

> Not until semester two did I know there are so many teaching methods in maths. Two lecturers, whose module I have attended, did introduce me to some teaching methods but did not include those introduced by you. (Appendix 5I4, page 471)

However, introducing some novel teaching methods to student teachers is desirable, and student teachers themselves thought likewise, as illustrated by E1's remark:

> Actually I don't know what my other lecturers are teaching and they are boring. I want to sleep in class. I think their modules are useless, but I think yours is useful....I talked about the "sandwich" approach and they said they have never heard of it. (Appendix 5H4, page 459)

Thus, my methodology class was different from some of the other classes that my students had attended: A classroom atmosphere had been created and knowledge construction had taken place. Findings from the critical friend for cross checking my interpretations of the foregoing results will be discussed in the next section.

Phase II – Critical Friend C'S Comments

In the second phase of implementation, my critical friend C continued to give encouragement and support to my interpretation of findings and to sit in my lessons. She also volunteered to conduct a focus group meeting in the last session (Thursday, 17 June 1999) – in my absence – in order to elicit genuine information from the 2SC-98 student teachers regarding their learning and the classroom environment. Notes on a particular lesson observation on Thursday, 11 March 1999 and the report on the results of the focus group meeting can be found in Appendix 5N (pages 494-497).

My Lesson

The sequence of activities in my lesson was recorded by C in Appendix 5N (pages 494-495). Both the comments added at the end of each activity and the overall comments on the observed lesson confirmed that I was following the procedures stipulated in my constructivist model: First, a problem – to teach the verification of an algebraic identity – was posed, and then student teachers tried to elicit their own teaching ideas. Afterwards, student teachers formed into groups to examine and to exchange their viewpoints. After the group consensus, presentation and class discussion followed. There were challenges from student teachers and defence from the presenters as well as from their group members. The lecturer summarised and provided further challenges, and the lesson was then concluded with student teachers reflecting on the content of the discussion and applying their constructed knowledge of teaching to verify the identity again. C commented:

> A constructivist approach was used....Students involved in a variety of interactive learning tasks. (Appendix 5N, page 495)

C described the learning atmosphere as free and non-threatening. I was commended by C as being enthusiastic and encouraging, and student teachers were observed as being used to the mode of teaching – behaving openly and actively in criticising and accepting suggestions (Appendix 5N, pages 494, 495). C felt that my lesson was "a highly interactive lesson" (Appendix 5N, page 495) that was readily accepted by the students and that "the L (lecturer) hardly interfered" (Appendix 5N, page 494) during the class discussion.

Constructed learning was presumed to be taking place, because C described the examination of views and exchange of ideas as a class activity that

> Provides challenges and maybe conflict, possibly leading to knowledge construction. (Appendix 5N, page 494)

She also asserted that student teachers should have developed not only cognitively but also in the affective aspects. C observed that some student teachers posed questions that were filtered and thought through, and that these student teachers had constructed new ideas about teaching. Moreover, C observed that student teachers seemed to have enjoyed the lesson. (See Appendix 5N, page 495.)

The Focus Group Meeting

The focus group meeting held at the end of the methodology session confirmed a number of the findings above and reported earlier in this chapter. Three themes were discussed: (1) opinion about the module, (2) experience gained during the teaching practice, and (3) views about mathematics teaching. C's report on the groups' opinions, together with the questions and themes for discussion, are attached to Appendix 5N (pages 496-497).

Student teachers remarked that they had numerous opportunities to air their own opinions and to discuss among themselves (Appendix 5N, page 496). This finding conforms to C's observation in my lesson dated 11 March 1999, in which my students were described as highly interactive (e.g., Appendix 5N, page 495). The finding could also be regarded as a justification of the high scores for the categories of LS (learn to air opinions) and LC (learn to communicate) in the CLE survey (e.g., see Figure 5.1, page 222).

The expert's role was more distinct in this second-phase implementation. Student teachers understood clearly my role as an expert giving my own ideas about teaching, and it is interesting to note a student teacher's remark:

> Students become the lecturer, and the lecturer an expert – the hidden role of the lecturer is to give expert ideas – highly professional ideas. (Appendix 5N, page 496)

They had also written a similar point about my role as expert in their journals as seen earlier (e.g., Categories 5 and 6 in Appendix 5M, page 492).

Learning about methodology (LM) (by building one's own teaching theories), learning to speak out (LS) and constructing one's own knowledge about teaching (by integrating negotiated knowledge) could also be clearly evidenced in the following extract from the report on the focus group meeting:

> We construct our own knowledge. Mr Fung did give his views (present the concepts) but we have our own views. We are allowed to use our views. Sometimes, we integrate with his. We hope to build up our own views/ways of teaching using his views. (Appendix 5N, page 496)

The report probably also explained why some of the specific teacher activities could not be used in the teaching practice (see Appendix 5N, page 496). My students could learn and use examples and new teaching sequences – for instance, the "sandwich" method. Student teachers found that they were not respected by the pupils they were teaching, and these pupils were not used to the new teaching methods they introduced in the class. Student teachers also ascribed their difficulties in applying these activities to their being inexperienced in teaching and to their preconception that mathematics teaching was an easy task:

> Formerly, we feel that mathematics teaching is very simple. Now we know that the process is very important. We have difficulties in using Mr Fung's methods in teaching our pupils because we have not enough experience, and we are not experts in teaching maths. (Appendix 5N, page 496)

The important "process" mentioned in this quotation was probably the teaching sequences – a clear statement of the pupil or teacher activities for learning a mathematics topic, the use of relevant and sufficient examples, non-examples and exercises, and the important points to stress during teaching (e.g., see Chapter Four, pages 179-180: "Journal Writing") – which they were required to articulate during class meetings and the various activities they were asked to pursue and incorporate in the teaching process.

Overall, student teachers found that much time was spent in class and group discussion, and yet they declared that it was still worthwhile because

> No other lecturer does this. If we listen, the lecturer may say a lot of things, but we did not learn any. We don't understand, and it is just useless. The time spent now is worthwhile. We build our own ideas, we understand better, and we are more involved. (Appendix 5N, page 496)

Overall Results (Constructivist Learning Environment, 1998-99)

This subsection summarises the preceding findings and my reflection regarding the constructivist learning environment obtained from the different methods of data collection, taking into consideration both confirming and disconfirming evidence. C's observations and comments were included. Findings in the two phases were also compared.

- The 2SC-98 students perceived in my lessons that there were often opportunities for learning to communicate (LC), to express critical opinions (LS), to learn about pupils' learning (LP), and to learn the teaching methodologies (LM). Sometimes, student teachers also perceived chances to control their own learning (LL). (The Phase II scores for the CLE questionnaire were similar to but slightly higher than those of the Phase I.) (See, e.g., Figures 5.1 and 5.2 on pages 222 and 224 respectively.)
- About three-quarters of the 2SC-98 students found journal writing effective for learning (Category 1 in Appendix 5M, page 492) but only half of the 2SC-97 students had a similar contention (Category 1 in Appendix 4K, page 399). (See also page 225: "Journal Writing" in this chapter; page 174: "Positive Outcomes" in Chapter Four.)
- All the 2SC-98 students welcomed group discussion, but only half of them liked group presentation (Category 2 and Category 3 in Appendix 5M, page 492). (Over 70% of the 2SC-97 students welcomed both, Appendix 4K, page 399.) (See also page 226: "Discussions" in this chapter; page 174: "Positive Outcomes" in Chapter Four.)
- Whole-class discussion was "less favoured" by the two cohorts. Sixty-nine percent of the Phase II students (Category 4 in Appendix 5M, page 492) and 40% of those of Phase I (Category 4 in Appendix 4K, page 399) considered whole-class discussion beneficial. (See also page 227: "Discussions" in this chapter; page 174: "Negative Outcomes" in Chapter Four.)

- Eight percent of the Phase II cohort, but 20% of the Phase I, considered time available was insufficient for discussion (Category 7 in Appendices 5M, page 493, and 4K, pages 399-400). (See also page 227: "Discussions" in this chapter; page 174: "Negative Outcomes" in Chapter Four.)
- The following responses which were present in Appendix 4K were absent in Appendix 5M (Categories 1, 2 and 7, pages 399-400 and 492-493 respectively): (1) guidance required, (2) change of members in a group and (3) better apportionment of time and content. This implied that relevant guidance and sufficient time given for self-articulation, self-reflection and group interaction were crucial factors for a successful constructivist approach. (See also pages 225-226: "Journal Writing" and "Discussions" in the present chapter; pages 174-175: "Negative Outcomes" in Chapter Four.)
- All three Case-98 students provided positive comments in their journals about the learning environment: warm, enthusiastic, lively, confidence building, useful for learning, can find the best method, expert ideas, modelling, new experience (e.g., see foregoing discussions on pages 227, 228, 230). (Similar to those found in Phase I, but with more descriptions; see page 174: "Positive Outcomes" in Chapter Four.)
- Overall, Class-98 members expressed the view that they could not apply the theories they learnt (Appendix 5N, page 496; pages 229-230: "Lecturer's Teaching"; pages 230-232: "Results from Case-98 Members' Interviews"; pages 233-235: "The Focus Group Meeting").
- C provided the following descriptions and observation of my Phase II lessons (pages 232-235: "Phase II – Critical Friend C's Comments"; see also Appendix 5N, pages 494-497) which were unlike those in Phase I: (1) The model of teaching was implemented appropriately (pages 233, 495); (2) the lessons were highly interactive (pages 233, 495); (3) students seemed to be used to such lessons (pages 233, 494-495); (4) students were found to be very often challenged, and hence learning was perceived to be constructed (pages 234-235, 494); (5) students enjoyed the lessons (pages 233, 495); (6) students understood my role as well as their role –

integrating old knowledge with new teaching ideas (pages 234-235, 496); (7) students explained the reasons for knowing but not applying – pupils did not respect them as new teachers, and they were not used to the methods newly introduced in class (pages 235, 496); (8) my lessons were worthwhile new experiences for student teachers – although much time had to be spent on discussion (pages 235, 496).

- Except for students' difficulty in applying their constructed teaching methods, the foregoing outcomes were generally positive. My retrospective reflection on the reasons for student teachers' inability to apply the learnt theories about teaching led me to a number of conclusions: (1) student teachers lack teaching experience; (2) the theories had not been adequately learnt; (3) there were too many teaching methods to be learnt; (4) pupils at school did not respect the new teachers when they used "unfamiliar" teaching methods with them; (5) the four weeks of teaching practice at secondary schools were insufficient.

In the next section, I will summarise the findings in the two phases of my study and give an overall evaluation of those research findings.

PHASE II – INTERPRETATION, RETROSPECTIVE REFLECTION AND EVALUATION

This section describes my interpretation and retrospective reflection of the "Overall Results" – which was a summary of the findings and reflections – at the end of each of the sections "Phase I – Student Teachers' Teaching Beliefs" and "Phase I – The Constructivist Learning Environment" in Chapter Four (pages 157-160 and 173-175 respectively) and of similar subsections in the present chapter (pages 216-220 and 236-238 respectively; see also my record of lessons and reflections in Appendix 5A, pages 403-428). This chapter concludes with an overall evaluation of the research study.

Beliefs About Teaching Mathematics

It was found that the Phase II cohort of student teachers, as well as the three members selected from the cohort (the Case-98 students), consistently responded more strongly to "agree (4)" than to "undecided (3)" or "disagree (2)" in the BTM surveys administered at the beginning and at the end of my methodology module, and the standard deviations were all about 1. The Phase I cohort of students displayed similar responses to the BTM surveys at the commencement of my methodology module, but their overall (average) scores decreased slightly at the end of the module. (See page 217: "Overall Results (Teaching Beliefs, 1998-99)"; page 157: "Overall Results (Teaching Beliefs, 1997-98)".)

Since the higher the average agreement score, the more learner-focused the students' orientation, the 2SC-98 student teachers inclined slightly more towards the socio-constructivist end of the teaching continuum. Their beliefs regarding their role in teaching would be more towards encouraging mathematical thinking and engaging pupils in active learning, rather than direct teaching, according to Van Zoest et al. (1994, pp. 42, 44, 47). These beliefs had not been changed at the end of the module. However, the Phase I student teachers became slightly more content-focused at the end of the module.

The standard deviations of about 1 found in the BTM results indicated that student teachers in the two classes varied their responses across the items (according to Van Zoest et al., 1994, p. 47). The variations implied that student teachers differed in the degree of importance they placed on their pupils' construction of knowledge through social interactions.

Analysis of student teachers' responses to the grouped BTM items showed that the two classes of students held invariant constructivist views about the role of a mathematics teacher and the role of questioning; otherwise, student teachers displayed indecision regarding the effect on pupils' learning of mathematics of (1) alternative mathematics ideas held by secondary pupils, (2) amount and order of presenting mathematics materials and (3) the nature of mathematics (see pages 216-220: "Overall Results (Teaching Beliefs, 1998-99)"). Thus, student teachers exhibited a teacher-centred orientation to teaching in addition to the learner-focused one. Moreover, the undecided and underdeveloped beliefs needed to be further addressed in mathematics teacher education – because they had an unwanted influence on student teachers' class teaching and possibly on their own learning as well (e.g., Nettle, 1998, p. 201). Often these student teachers' stated beliefs may be different from their displayed teaching performance (e.g., Artzt, 1999, p. 148; Van Zoest et al., 1994, p. 42).

The different teaching ideas held by different student teachers in the two classes were witnessed in their stated general teaching sequences in answering the GTS questionnaires and in explicating teaching ideas in their journals. This finding also echoes the observation by Loughran (1996, p. 14) and a number of other researchers. The Phase I general teaching sequences showed no particular patterns in student teachers' displayed beliefs – the teaching orientations oscillated between the learner-interaction and content-performance ends of the teaching continuum as the module progressed. In Phase II, the content-performance-focused orientation prevailed throughout the module, with a slightly growing acceptance for the discovery approach towards the end of the semester. (See page 217: "Overall Results (Teaching Beliefs, 1998-99)" in the present chapter.)

Furthermore, in their journals, I observed improvement in the descriptions of how teaching could be conducted. In Phase I, for example, student teachers displayed little use of examples and non-examples in teaching, and there was very little emphasis on how concepts, skills and the other important mathematics processes could be constructed by pupils. In Phase II, student teachers became more aware of documenting the important points that needed to be stressed. They also intertwined the original stated (usually expository) teaching sequence with sufficient, relevant and related examples. (See pages 219-220: "Overall Results (Teaching Beliefs, 1998-99)".)

The lesson observation and discussion with the case study groups (Cases) during the teaching practice in each phase of the implementation aimed at studying the actual application of what student teachers learnt in my methodology classroom. Real class teaching performance was only satisfactory, and I found that all students of the Cases carried out a direct teaching sequence (page 220: "Overall Results (Teaching Beliefs, 1998-99)"). In the post-lesson discussion, both S2 and E2 admitted that they believed direct teaching was effective in their class of pupils. S2 even rejected the discovery approach totally, because his class was chaotic if such an approach was used. E2 did not change her teacher-centred belief, and she even encouraged reciting as one of the means in learning mathematics. The other student teachers in the Cases still retained their own teaching beliefs – pupils as knowledge constructors and teachers as facilitators as well as mediators of learning. (See page 156: "Summary (Case Members' Beliefs, 1997-98" in Chapter Four and a similar subsection in the present chapter, pages 215-217. In particular, for responses by S2 and E2 in the lesson observation and discussion, see pages 151-153 and 209-211 respectively.)

During the interview, the Case students acknowledged the influence of the actual classroom teaching on their beliefs – this accorded with the claim by Edwards and Hensien (1999, p. 189). After the teaching practice, the Phase I Case students revealed the unanimous belief that their pupils had no motivation in learning mathematics; whereas E1 and E3 in Phase II found that their original belief that teaching mathematics was simple had proved to be false (see page 220: "Overall Results (Teaching Beliefs, 1998-99)"). The Case students in Phase II also realised that even if teachers know the relevant mathematics and its related specific teaching methods, they could not easily carry out the teaching (e.g., Ebby, 2000; see page 238: "Overall Results (Constructivist Learning Environment, 1998-99)"). However, E2 believed in the method of transmission, and held to that belief when interviewed (pages 210-211 of the present chapter).

The focus group meeting conducted in Phase II confirmed the finding that student teachers acknowledged their inexperience in teaching, and that they could not apply the teaching methods learned too successfully. My students further claimed that they had not been respected by their pupils in the schools where they were practising and that the class of pupils could not adapt to the teaching methods used (in the four weeks of teaching by my students) – which were quite different from those used by "other" teachers in the schools concerned. (See page 220: "Overall Results (Teaching Beliefs, 1998-99)"; page 238: "Overall Results (Constructivist Learning Environment, 1998-99)".)

I would also ascribe Case-97 and Case-98 members' performance in teaching to their lack of experience as facilitators of pupils' learning (see page 238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter) and the fact that the easiest solution to teaching is by direct exposition, because preparation is much easier. Direct transmission requires only a minimal amount of interpersonal, social and communication skills; skills that were seemingly inadequate in beginning teachers (which is my retrospective reflection). Moreover, the pupils in the school and the school teachers influenced how the student teachers performed instruction (see page 220: "Overall Results (Teaching Beliefs, 1998-99)"). However I observed that, in general, student teachers of the Cases did strive, whether successfully or not, to provide questioning, challenges, examples and activities to facilitate their pupils' learning – revealing perhaps a constructivist perspective (see pages 219-220: "Overall Results (Teaching Beliefs, 1998-99)"; pages 237-238: "Overall Results (Constructivist Learning Environment, 1998-99)").

The Creation of a Social Constructivist Learning Environment

Student teachers' perceptions of the various learning activities in my methodology classroom were in general positive, and their responses appeared to describe a social constructivist learning environment (see pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter). If the five categories of learning in the CLE survey were ranked in descending order of mean frequency scores (that is, becoming less frequently occurring), then both members of Class-97 and of Class-98 (Classes) gave the same rank order: LC, LS, LP, LM and LL, with some of the Phase II averages scoring slightly higher than those of the Phase I (see Figure 5.2, page 224). The minimum score was about 3 (at LL), which indicated that my two Classes of students held positive perceptions of some learning activities that were designed according to my model of teaching. As also seen in this chapter and from various entries in the journals that described these classroom learning activities – mainly comprising self-articulation, self-reflection and social interactions among student teachers and with the lecturer – the designed model could facilitate constructed learning (pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)").

The various learning activities will be discussed and evaluated under the subsections LC, LS, LP, LM and LL.

Learning to Communicate (LC)

Both the 2SC-97 and 2SC-98 students gave average frequency scores of above 4 (respectively 4.0 and 4.3 with standard deviations of about 1), which corresponds to "often", to the category of learning to communicate (LC). The relatively high scores implied that my students perceived that "often" there were opportunities for both group and class discussion, despite the existence of variations of responses over the whole scale (see pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)").

Self-articulation and Self-reflection

Self-articulation on the methods of teaching a certain junior secondary mathematics topic was a preliminary activity for group discussion, group presentation and class discussion (e.g., see Figure 2.1 in Chapter Two, page 43). As "new recruits" (seen from their personal details, Chapter Three, Tables 3.3 and 3.12, pages 87 and 108 respectively), my first-year students had no teaching experience, and it is not surprising that they would need some time to articulate their prior knowledge about teaching. In most cases, they would express their views based on either imagination or recall of what their former mathematics teachers did in mathematics lessons (page 220: "Overall Results (Constructivist Learning Environment, 1998-99)").

The difficulties in articulating the teaching points (Grant, 1984, p. 13) had already been evidenced in the Phase I journals (with the Case students' journals, particularly S2's which echoed likewise, included; see Chapter Four, pages 163-164: "Journal Writing") and in the critical friend's observation, but they had not been expressed in Phase II journals, nor had they been observed by C (pages 237-238: "Overall Results (Constructivist Learning Environment, 1998-99)"). Nevertheless, there was some evidence found in my record of lessons, for example:

> Another student teacher said, "I can draw it myself, but I cannot explain to pupils how I do it". (Appendix 5A, Thursday, 4/3/1999, page 408)

and

> And yet another student teacher said, "I cannot articulate at all". (Appendix 5A, Thursday, 4/3/1999, page 408)

The two following student assertions quoted from my records also implied student difficulties in articulating their teaching beliefs:

> [You] should ask them to prepare and read up books first before the articulation of teaching. (Appendix 5A, Thursday, 4/2/1999, page 404)

and

> [You] should let student teachers prepare the lesson before coming to the meeting. (Appendix 5A, Thursday, 8/4/1999, page 413)

Surprisingly, the latter student added that he would not have done any preparation himself even if requested (Appendix 5A, Thursday, 8/4/1999, page 413).

In Phase II, more time had been given for self-articulation as well as for self-reflection (20 minutes given, which doubled the time in Phase I); a set of guidelines had also been given to the students (see Chapter Four, pages 179-180: "Journal Writing"). From my observation (in my record of lessons in Appendix 5A, pages 403-428), student teachers could not write the important teaching points clearly in the first few meetings; they could only concentrate on the teaching sequence (Appendix 5A, Thursday, 4/2/1999, pages 405-406). Student teachers were found to have the same difficulties as the module progressed (Appendix 5A, 8/4/1999 and 20/5/1999, pages 413 and 419); however, they became more aware of stating and planning the teaching points, the teaching sequences and examples used in greater details (Appendix 5A, 27/5/1999 – 10/6/1999, pages 420, 421, 423; pages 219-220: "Overall Results (Teaching Beliefs, 1998-99)" in the present chapter).

Discussion

More time had also been given to students for group work, presentation and class negotiation in Phase II (pages 179-180: "Journal Writing" in Chapter Four). The use of only a single common familiar mathematics topic for whole-class discourse (pages 179-180: "Journal Writing" in Chapter Four) probably also facilitated constructivist learning. As everyone in the Class-98 was assumed to have learnt the topic before and the whole class had gone through initially both a personal examination and group discussion of its teaching methods before class discourse, student teachers could be trusted to carry out the tasks of defending, criticising and negotiating more competently.

Group discussion was in general enthusiastic, and every group member seemingly enjoyed the process, as observed by me (e.g., Appendix 4C, 23/2/1998, page 336;

Appendix 5A, 4/2/1999, 11/3/1999 and 1/4/1999, pages 404, 409 and 412 respectively; page 237: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter). Students in the Cases in both phases also acknowledged the benefits of group discussion and perceived the frequent opportunities for group negotiation as desirable (pages 237-238: "Overall Results (Constructivist Learning Environment, 1998-99)"). My critical friend, C, also found discussion taking place in the two phases (page 174: "Overall Results (Constructivist Learning Environment, 1997-98)" in Chapter Four, and a similar subsection in the present chapter, pages 237-238). She observed a decline of interest in group discussion in the lessons in Phase I, whereas she reported nothing of the same nature in Phase II (page 238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter). I had experienced a similar "misbehaviour" in the first meeting in Phase II in which two female student teachers were unwilling to participate in the group discussion (Appendix 5A, 4/2/1999, page 404); the situation improved as the module progressed (e.g., see page 411 in Appendix 5A, 25/3/1999). Unless student teachers engaged actively in group discussion, I was afraid that viable construction could not take place (page 408 in Appendix 5A, 4/3/1999). This view is maintained by Bauersfeld (1995, pp. 137, 152).

The group leader's presentation involving class discussion was also acceptable to the majority of 2SC-98 students. When a presentation was poor, for instance, in session six (Thursday, 25 March 1999), the presenter was challenged. I urged my students to respect others' opinions, to tolerate different assertions and to query the ideas raised, but not to attack the person (e.g., Appendix 5A, 25/3/1999, page 411). Afterwards, class discussion became more interesting and active, and everyone in the Class was very attentive and responded rigorously. I believed that an empathetic and safe environment that encouraged students to disclose and discuss their own ideas about mathematics teaching was created – "some formerly rather quiet student teachers also tried to voice their opinions" (Appendix 5A, 25/3/1999, page 411) because they were also motivated.

The established "rule" concerning discussion seemed to take effect immediately in the next session. Group leaders' presentation skills were in general good:

> Most student teachers were calm, spoke at a right pace, and were convincing. (Appendix 5A, Thursday, 1/4/1999, page 412)

and students were

> Willing to talk and respond and sometimes even rigorously but without any hard feelings about one another. (Appendix 5A, Thursday, 11/3/1999, page 409)

Later in May,

> I found also that more student teachers were willing to talk when compared to the first few meetings. (Appendix 5A, Thursday, 27/5/1999, page 420)

There was a skill in presentation which is worth noting. According to my record, a student teacher remarked that the group which presented last could have nothing to say if all the previous groups had elicited and elaborated every point (Appendix 5A, Thursday, 4/2/1999, page 404). This worry was sensible; Class-98 members were then advised to trust that their peers would understand the situation and that usually, different people could possibly present even the same ideas in a different but similarly interesting manner.

I observed group members defending their teaching ideas as did C in the second phase (page 237: "Overall Results (Constructivist Learning Environment, 1998-99)"). A sense of belonging to and confidence in the group seemed to have been developed when members were sustained in the same group for the whole semester. Probably the Chinese belief in group harmony (e.g., Chan, 1999, p. 299) tied the members together.

Towards the end of the second phase, my records informed me that discussion was still very active, but it was more systematic than before (Appendix 5A, Thursday, 3/6/1999, page 421; Thursday, 10/6/1999, page 423). However, there was still some evidence to the contrary.

A study of the written descriptions about my methodology classroom, as already mentioned, showed that there was a minority of dissident students (about 20% of the respondents in each Class, including S3 and E3) who perceived differently the group report and class discourse. Comments found were: too much time was spent possibly due to unsatisfactory apportionment of time and content for discussion (by S3, page 167: "Lecturer's Teaching" in Chapter Four), and individuals could not be taken care of in whole-class discussion (by E3, page 228: "Discussions" in the present chapter).

The other dissident I found in my record had a different viewpoint about the conduct of my methodology lesson. He maintained that lectures could save student teachers' "face":

> [You] should use lectures in class since if student teachers did not know the answers to the questions, then they would be very embarrassed. (Appendix 5A, Thursday, 8/4/1999, page 414)

This "face" issue echoes the Chinese fear of being criticised and ridiculed by others and imposes unbearable pressures on an individual (e.g., Gao et al., 1996, p. 290).

The avoidance behaviour persisted in the Phase II students even towards the end of the methodology module. It was true that "two or three student teachers never tried to speak out in class and contribution to discussion was only voluntary" (Appendix 5A, Thursday, 27/5/1999, page 420), although it was also recorded that a greater number of students in the Class at this stage were more willing to participate, when compared to earlier observations.

Lecturer Intervention

My input during group and class discussion was also an item for my students to write about in their journals in Phase II – there had been a paucity of such descriptions in Phase I (see pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter). This could imply that I had played a more distinctive role in the second phase – an improvement in my teaching as well as my role being better realised by my students. Moreover, as seen in several places (pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter), student teachers found my input helpful in providing expert ideas about teaching – in clarifying teaching points and in putting a wide variety of ideas across. Critical friend C also found my input challenging and commented that it could facilitate further discussion, negotiation and personal knowledge construction (page 237: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter).

I found that my intervention in a group assisted self-articulation, self-reflection, perturbation, rethinking and new knowledge construction. With about only four student teachers in a group, I was able to read some of the journals and provide immediate feedback in the form of questions. For instance, after my intervention, E1 added some pupil activities into the teaching sequence, and another student teacher inserted relevant teaching points in the solution procedures in solving simultaneous equations (Appendix 5A, Thursday, 4/2/1999, page 404).

I could also observe my student teachers' inadequacies regarding their ideas about mathematics teaching while I sat in a group discussion. For instance, in the second session (4 February 1999), I found that student teachers concentrated on discussing the introduction and previous knowledge part of their teaching plan, neglecting the main theme of their teaching (Appendix 5A, Thursday, 4/2/1999, page 404).

On the same day, I also discovered that student teachers seemed to lack the skills for negotiating for a common acceptable teaching method. Some even could not express their teaching points clearly. I also found that in one group, the male students dominated the discussion, and in another, two female students did not participate at all (Appendix 5A, Thursday, 4/2/1999, page 404). Thus, I suggested that the Class should seek a balance in allowing every one in the group to voice their opinion, and that the Class should also learn to negotiate for a consensus within a given period of time. These points were also noted and stressed during the rest of the class sessions of the methodology module.

In the class discussion in this second session, I also found that my students could not link the various stages in the presented teaching sequences. The various activities were disjointed, and the passage from one stage to the other was abrupt and disorderly. Moreover, the groups' negotiated teaching sequences revealed a predominance of teacher-centredness (Appendix 5A, Thursday, 4/2/1999, pages 404-405); superficially, a more learner-focused orientation was not part of my students' beliefs, at least at the very outset of my methodology module.

I learnt to focus on the main points and at the same time stimulate further thinking in class. For instance, in session 5, student teachers were discussing whether the discovery approach or exposition was more motivating, and the discussion was so rigorous that intervention was almost impossible (C considered my intervention already too late). I tried to pose the questions:

> If you find that an approach is not interesting, what should you do? (Appendix 5A, Thursday, 11/3/1999, page 409)

and

Could you reflect your opinions in your journals? (Appendix 5A, Thursday, 11/3/1999, page 409)

C later commented on my late intervention, although she observed that my input was sufficient and relevant. Prompt responses and injection of my own ideas were crucial in the classroom (of Chinese learners) – something that I learnt from the Class-98 students and from C.

In the two phases of teaching, I also observed that classroom fixtures, for instance, tables and chairs, hampered my intervention during group discussion (Appendix 5A, Thursday, 4/2/1999, page 406). The physical environment made it difficult for me to move closer to individual student teachers when I wished to raise questions with any of them.

Overall, the tempo of the lessons in Phase II was moderate and was much slower. In Phase I teaching, I had to hurry through all the different learning activities within the assigned period of time in almost every class session (Appendix 5A, Thursday, 4/2/1999 and Thursday, 11/2/1999, pages 406 and 407 respectively). The use of only one topic for discussion and the shortening of time in the briefing for assessment were all sensible changes in the second phase – to allow more time for student teachers' activities. Every activity was conducted more slowly, and students found more time to think through their teaching points carefully. I could also provide more of my own ideas to Class-98 members; the student teachers probably perceived this as support from me, which helped them to construct and reconstruct their own experiences and learning.

Learning To Speak Out (LS)

The environment developed in the methodology classroom in the two phases was sincere and non-threatening (see pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter) and it gave the impression to student teachers that they could express their own opinions, question the lecturer for an answer and speak up for their own rights. The communication style nurtured thus resembled the LC category in the CLS survey, and hence it was not surprising that the LS category ranked next to LC.

In both Phase I and Phase II, my sincere disposition and student teachers' positive attitudes probably fostered an atmosphere in which students had confidence to air their own opinions. Members of the Classes appreciated the freedom to describe their own teaching points in front of their peers and their lecturer, to negotiate for consensus and to adopt others' viewpoints without any feeling of humiliation (see pages 236-238: "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter). Differences in opinions were tolerated.

Members of the Classes being invited to comment on and discuss the various learning activities in each phase (for instance, in their journals, informally during and after class meetings, in the official end-of-term module evaluation) was also a sign of respect for student teachers' opinions. The student teachers were told that their comments would be considered carefully – to improve my teaching, and any data collected would be kept secure and confident (see Chapter Three, pages 111-112: "Ethics").

Presumably Chinese students seldom question the way they are taught and neither do they complain about anything that is confusing and prevents them from learning. Individual assertion in class that challenges the teacher is a sign of disrespect for the teacher (in my case, the lecturer) and is usually avoided (e.g., Chan, 1999, p. 298; Pratt et al., 1999, pp. 246-247). This cultural belief perhaps explains the slightly lower score for the category LS. However, written channels, in addition to verbal ones, had been provided in my Class; E3 did use the written channel to express his opinion about discussion in class sessions (as seen in the subsection "Discussions" in the present chapter, page 228).

Learning About Secondary Pupils' Learning (LP)

The problems posed to members of the Class for articulation were related to junior secondary classroom teaching in Phase II, but the teaching topics assigned in Phase I were not directly related to junior secondary teaching (see page 178: "Topic for Self-articulation" in Chapter Four). The situation, although improved in the second phase teaching, did not score highly in the CLE survey (e.g., see Figure 5.2, page 224). The time constraint, a predetermined syllabus and the assessment structure of this methodology module rendered it difficult to train my student teachers in self-articulation, construction and reconstruction of ideas about how a variety of mathematics topics could be learnt by pupils.

Learning About Methodology (LM)

The time constraint could not allow the Classes of students to have a more in-depth discourse on the various teaching methodologies relating to both the learning theories and the different mathematics topics in junior secondary schools. Hence, student teachers' ratings of the opportunities given for learning about these methods of teaching ranged only between "sometimes" and "often" (e.g., see Figure 5.2, page 224).

The lack of experience in teaching and the lack of opportunities in implementing and testing these new teaching ideas are probably obstacles for a true and deep knowing. Thus, similar to the first phase findings, explicit use of teaching methods learnt in the module could not be identified in the second phase. However, the use of examples espoused in most of the specific teacher activities, and the stress of important teaching points in the simulated teaching process could be found in the 2SC-98 Class's journals. (See page 219: "Overall Results (Teaching Beliefs, 1998-99)" in the present chapter.)

My own belief about mathematics teacher education is that my students should get acquainted with a number of the teaching and learning theories in mathematics, try them out, and develop and construct their own as experiences accumulate; and through modelling, I anticipate that student teachers could construct more learner-focused ideas about teaching mathematics that way. After this study, I found that the 2SC-98 students understood my ideal as well as their own role as active learners (pages 237-238: "Overall Results (Constructivist Learning Environment, 1998-99)" and page 219: "Overall Results (Teaching Beliefs, 1998-99)") and that they could display a general sequence of teaching that engaged their pupils in learning activities (page 219: "Overall Results (Teaching Beliefs, 1998-99)") – activities that I felt reflected a constructivist orientation. For these first-year students, I was convinced that learning had been facilitated.

Over time, I anticipate that my students will be able to construct their own methods, probably based on these teacher activities. As long as they are active learners and undertake reflections on their own experiences and inadequacies, then with more experiences in teaching and with a positive learning attitude (which they did possess, see page 219: "Overall Results (Teaching Beliefs, 1998-99)") and sincere understanding of their pupils, I believe that they will excel in teaching mathematics.

My expert role in this study was manyfold:

- as a facilitator and a mediator who could pinpoint important teaching points that could be overlooked by my students;
- as a contributor of my expert knowledge regarding learning theories and teaching methods;
- as a mediator to demonstrate my tolerance of differences in teaching ideas; and
- as a provider of challenges for confrontation and reflection.

It was thus natural that when my students could not articulate in class (as seen earlier in several places, e.g., Appendix 5A, Thursday, 4/3/1999, page 408; page 174: "Overall Results (Constructivist Learning Environment, 1997-98)" in

Chapter Four), and when I did not respond and give the "answers" immediately (according to my constructivist beliefs and philosophy, I would rather ask questions and provide challenges), my students might have mistakenly seen me as not having carried out sufficient preparation, and therefore considered my teaching as ineffective. As a consequence, my students presumably assumed that there were insufficient opportunities for learning the methodology for mathematics teaching. Chinese students wish to be taught; and yet my mediation was, according to Lerman (1998, pp. 337-339), crucial in leading them to learning new approaches to teaching.

Learning To Learn (LL)

Student teachers gave comparatively lower scores to this category of learning to learn, particularly in Phase II, at the end of which the range of scores by both members of the Class-98 and the Case-98 was between 2.3 and 2.8 (e.g., see Figure 5.1, page 222). The results implied that students perceived few opportunities to control their own learning – to plan what to learn, and to decide on the activities that best suited their learning.

The methodology module did not involve students in selection of my teaching strategies and in deciding on the type of assessment tasks. The strategies were already designed and decided solely by me, to enable me to conduct action research to improve my teaching method (as was made clear to my students at the very outset), while the latter was mandatory and had to be enacted in the methodology class.

As seen earlier in this chapter (page 244: "Learning to Communicate (LC)"), some student teachers did try to persuade me to let them prepare the teaching materials at home before the actual discussion; some also requested more time to write their journals at home. However, I decided not to engage my students in my research outside the methodology class hours, except when I deemed it necessary.

I was afraid that my students might spend too much time on my assigned tasks, therefore sacrificing other on- and off-campus activities.

There was flexibility in some respects (although only a few in student teachers' opinions). For instance, in Phase II, the number of students forming a group and the choice of members in the group were all voluntary; student teachers could choose their own group of friends (see pages 181-182: "Group and Class Discussion" in Chapter Four).

There were clearly students in my Classes who did not want to participate in the class activities – for instance, C observed a decline of interest in group discussion in my lessons in Phase I, and my observation of two female students who were not willing to participate in class in Phase II (see foregoing discussion in "Discussion", pages 245-247). However, these student teachers were encouraged and not blamed. They were able to voice their feelings via a number of channels. Their opinions were respected as was their responsibility for their own learning, and all class activities were optional. I am convinced that student teachers did not have the impression that the learning activities conducted in my methodology classroom were only intended to assist my research.

The Appropriateness of the Constructivist Learning Model

To end this section, I list some of the Phase II students' feelings and recollections about my lessons that I recorded when I joined their group discussions and in conversations with them on Thursday, 1 April 1999 – the last meeting before the class assessment (Appendix 5A, Thursday, 1/4/1999, page 412):

> I would not like to skip this lesson.
>
> I can talk freely during the lessons.
>
> I can learn from others.

> I can learn how to draw conclusions and come to consensus with my peers.
>
> I can question more critically my peers' presentation, methods of teaching, etc.
>
> I can overcome my fear of speaking in class.
>
> Other maths lessons are boring; you cannot learn anything.
>
> If I can grasp the general method, then I can always plan a lesson smoothly!

I consider my model for teaching in a first-year methodology class relevant to and suitable for my Chinese students.

The final chapter summarises the major findings on the implementation of a constructivist approach, discusses the significance and limitations of this study and concludes with a discussion of the implications of the study for teaching and learning and recommendations for future practice.

CHAPTER SIX

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

This study employed a two-phase action research procedure as a means of investigating the efficacy of a constructivist approach to the teaching of a methodology class of first-year Chinese student mathematics teachers in the Hong Kong Institute of Education (HKIEd). The study commenced with an exploration of both the beliefs held by a cohort of first-year students enrolled in the 1997-98 academic year, and their perceptions of the learning environment created according to my social constructivist model. The findings obtained in this first phase were used to inform implementation of the second phase involving a new cohort of first-year students taking the same methodology module in 1998-99. The second phase consisted of the retrial of my teaching and an evaluation of my research study.

An instructional model based on the theory of social constructivism takes the perspective that learning is a creative human activity and that social interaction plays a crucial role in learning. On the basis of this learning theory, I tried to provide an abundance of student-student and student-lecturer interactive opportunities in my methodology class to enable my student teachers to build up their own approaches to teaching mathematics. I did this because I was sure that the interactions between me and the student teachers and between themselves influenced what they learnt and how they learnt. I played a crucial role by guiding the development of a social interactive atmosphere, an environment in which my students were free to talk about their teaching beliefs. I was also instrumental in establishing a norm among the student teachers that stressed to them that assisting their peers to learn was a central element of their tutorial room roles. Once this norm was established, opportunities for learning (not usually present in traditional tutorial rooms in HKIEd) arose, as student teachers collaborated to solve problems in teaching mathematics.

Student teachers learnt more in this type of tutorial room setting than in the traditional approaches to teaching mathematics taught to Hong Kong preservice teachers. They developed beliefs about teaching mathematics and about their own role and their lecturer's role. In addition, a sense of what was to be valued was developed, along with attitudes and motivation: collaboration, cooperation and negotiation between students were valued over competition and conflict. The approach of encouraging student teachers to talk about their own teaching ideas without being evaluated as right or wrong allowed the development of a mutual trust between student teachers and me. I trusted my students to persist in improving their own teaching methods, and consequently I felt free to call upon them to describe their thinking. My students saw that I respected their efforts, and as a result entered into discussions in which they explained how they actually understood and attempted to resolve their own teaching problems. Above all else, my students understood that they were fully encouraged to experiment with, and formulate their own theories of teaching.

To conclude the thesis, I answer the four research questions that were posed in Chapter One (page 17). They are restated here for ease of reference:

1. How entrenched are Chinese student teachers' beliefs and practices regarding the teaching of mathematics?
2. Is the constructivist approach appropriate to use with a class of first-year preservice teachers of mathematics at the junior secondary level (i.e., for pupils between 12 and 15 years of age)?
3. Can the constructivist approach also develop a social environment in the methodology classroom?

4. What are the implications of the study regarding teaching and learning for Chinese teachers of mathematics?

Findings in Chapters Four and Five will be summarised and employed to answer questions 1 to 3. The significance and the limitations of the present study will be discussed, and implications and recommendations drawn, in order to provide an answer to question 4.

QUESTION 1: BELIEFS ABOUT TEACHING MATHEMATICS

How entrenched are Chinese student teachers' beliefs and practices regarding the teaching of mathematics?

My critical colleague and I found that the two Classes of roughly 20 first-year Chinese student mathematics teachers, in the two phases of my study, appeared to inwardly possess a constructivist orientation to teaching, although their displayed beliefs differed across the 33 belief statements in the BTM questionnaire (as reflected by the calculated mean scores and standard deviations) and in their journals, where they were requested to document their own self-articulation and reflection (e.g., see pages 239-241: "Beliefs About Teaching Mathematics" in Chapter Five).

There were unchanged beliefs held by the two cohorts of students (e.g., see pages 239-240: "Beliefs About Teaching Mathematics" in Chapter Five) – a finding which echoes the many reports in the literature regarding entrenched beliefs held by western student teachers about teaching and learning (Ebby, 2000, p. 70). Invariably, these Chinese students professed a learner-focused belief about the role of a mathematics teacher in the creation of a non-threatening environment to facilitate the exploration of mathematical knowledge. They agreed that persistent questioning would be effective in assisting their pupils in knowledge construction. They also believed and accepted their pupils' generally possessed different mathematical ideas and thinking, but they were uncertain about the effect of acknowledging these multiple perspectives in teaching.

Other entrenched beliefs possessed by the two Classes of student teachers that were worthy of attention were their (mis)understanding of (1) the nature of mathematics, (2) the content of mathematics to be presented to the pupils, and (3) the way mathematics materials could be presented (e.g., see Chapter Five, pages 218-219: "Overall Results (Teaching Beliefs, 1998-99)" and pages 239-240: "Beliefs About Teaching Mathematics"). Student teachers indicated that they could not decide whether (1) mathematics is a coherent structure of concepts and skills (page 219), (2) learning mathematics requires no memorisation (page 219), (3) mathematics problems can be solved without using rules (page 218), and (4) there should be a fixed amount of mathematics to teach a particular grade level of pupils (page 218). In determining the proper sequence and means of teaching mathematics, particularly in the effectiveness of an expository approach involving demonstration and explanations, students' beliefs were also problematic (pages 217-218). Are these beliefs indications of student teachers' inadequate learning in both mathematics content and teaching methodologies? If so, how can the situation be improved in mathematics teacher education? These are all questions requiring careful thought – especially because of the paucity of research on how Asian teachers are prepared (e.g., Cooke, 1998, p. 3; Morris & Williamson, 1998).

It also appeared that the student teachers were sometimes inclined to employ more teacher-centred than student-centred approaches to teaching mathematics. This outward behaviour was particularly demonstrated in their journals (e.g., see page 240: "Beliefs About Teaching Mathematics"). The agreement scores for the BTM questionnaire had already indicated the dubious nature of their beliefs about demonstrating, explaining and describing concepts (see the previous paragraph), while in their journals (in which the student teachers expressed the teaching sequences and activities they intended to use for teaching a given mathematics topics) the two Classes of teacher trainees showed that they used different approaches to teaching. In particular, content-focused approaches were often preferred. Such an instability of beliefs provides further support for the findings of researchers such as Artzt (1999, p. 148) and Van Zoest, Jones, and Thornton (1994, p. 42).

In the actual classroom teaching, the case study subjects (three selected outstanding students in each cohort) displayed a traditional approach to teaching (e.g., see pages 241-242: "Beliefs About Teaching Mathematics" in Chapter Five). Outwardly, their performance demonstrated a teacher-centred orientation (page 241), but during the post-lesson discussion with me, during the end-of-module interview and during the focus group meeting conducted by my critical friend, a majority of these students invariably expressed their intention to offer far more pupil activities than they had demonstrated in the classrooms (pages 241-242). In the general teaching sequence they showed awareness of the use of examples and exercises for knowledge construction, and the vital points to note in their teaching (page 240). However, they declared that they could not implement the planned (leaner-interactive) activities – which conformed to findings by Artzt (1999, p. 148) and Van Zoest et al. (1994, p. 42) – because of their lack of teaching experience (page 241-242). Some of these best student teachers also attributed their "unsuccessful teaching" to the behaviour of the pupils during the lessons, and to the mentors in the school who observed their lessons and gave help and advice to their teaching (page 242).

From these case study reports during the post-lesson discussions, the end-of-module interviews and the focus group meeting, it appeared that the school environment, the school culture, the pupils and the teachers in the schools were probably crucial factors that could discourage my student teachers' original learner-focused views about teaching mathematics. Nettle's (1998, pp. 200, 202) suggestion to explore the influence of such factors on belief change and stability is appropriate and, in the context of this research, worthy of further study.

The methodology classroom which I created in the two phases of implementation provided new ideas and experiences for my students. At the conclusion of the methodology module, a number of my students in both cohorts expressed the view that they were very well motivated in the classroom setting – they really enjoyed the sessions – an experience they had not had in other class sessions at HKIEd. The two Classes seemed to recognise the effect of a constructivist learning environment in stimulating interest in learning and providing abundant learning opportunities. (See, for example, Chapter Five, pages 256-257: "The Appropriateness of the Constructivist Learning Model", and pages 236-238 "Overall Results (Constructivist Learning Environment, 1998-99.)

In the focus group meeting organised by my critical colleague in the second phase, the 2SC-98 students began to recognise that my role as their lecturer in the tutorial room setting was something new – a facilitator of learning, an expert in teaching mathematics and a mediator of conflicts and disputes (see my teaching belief in Chapter Five, pages 253-254: "The Creation of a Social Constructivist Learning Environment"). They further demonstrated their understanding that they themselves had to be active and proactive learners in order to benefit from the various activities – for instance, in the group and class discussions. They also learnt that they were helping one another in their learning by expressing their own teaching ideas, by listening to others' ideas and by integrating the new knowledge into their old prior beliefs. But most important of all, the 2SC-98 first-year student teachers actually realised that they were not to be taught or prescribed with particular approaches to mathematics teaching; rather, they understood that they were to construct their own teaching approaches by reflecting continually on their own teaching experiences, thus developing in themselves an attitude of inquiry and lifelong professional learning. My critical friend's finding in this respect (as stated in the subsection "Overall Results (Constructivist Learning Environment, 1998-99)" in the present chapter, pages 237-238) concurred with my own teaching belief.

Thus in answer to Research Question 1, the results of the study confirm that:

First-year Chinese student teachers possessed entrenched pupil-centred beliefs about teaching mathematics. They recognised their role as learners who actively constructed their own knowledge about teaching mathematics through social interaction, and they acknowledged my role as a facilitator and mediator of their learning. Their displayed teaching behaviour, however, was unstable and was affected by their own inexperience, the sustained learning experience in HKIEd and in the school in which they had their teaching practice experiences.

QUESTION 2: THE EFFICACY OF THE APPROACH

Is the constructivist approach appropriate to use with a class of first-year preservice teachers of mathematics at the junior secondary level (i.e., for pupils between 12 and 15 years of age)?

The focus of my inquiry in the present research study was to investigate whether my (constructivist) approach to teaching could be effective in enabling my students' construction of their own teaching beliefs (beliefs preferably conforming to those of the learner-focused teaching orientation) – which indicated student teachers' learning. Results in the Phase I implementation of action research enabled me to improve on my teaching (and data collection methods) in Phase II, and thus interpretation of the Phase II results allowed me to confirm the positive impact of my teaching approach on my students' learning. In the following discussion, my focus will be on the Phase II results.

As seen in Chapter Five (e.g., pages 216-220) and in the previous section (pages 260-264), there were entrenched beliefs held by the Phase II cohort of students as well as belief changes demonstrated by them. The 2SC-98 students, though possessed a variety of teaching beliefs, collectively displayed stable learner-focused orientations when the BTM results were analysed (page 217). Unanimously, they agreed that a mathematics teacher should be a facilitator of learning – by creating a non-threatening environment in which there were opportunities for pupils to explore freely their own mathematics ideas (page 188).

They continued to have high regards for teacher-pupil and pupil-pupil interactions in facilitating pupil learning mathematics. For instance, persistent teacher questioning was considered effective in assisting their pupils in knowledge construction (page 188), so was small group dynamics (pages 189-190).

The Phase II student teachers confirmed that they believed that their pupils actually possessed different interpretations of a mathematical idea, but they were afraid of acknowledging these idiosyncratic ideas brought to the class (page 192). They were uncertain if justification of different ideas might confuse their pupils and hence requiring pupils to justify their viewpoints might be ineffective in pupil learning. Consequently, the Phase II students showed their continued indecision about the effectiveness of the expository approach in teaching mathematics (BTM result, pages 190-191). This indecisiveness possibly led them to give two different teaching sequences (exhibiting different teaching perspectives) in the GTS questionnaires and in their journals (pages 217-218). Yet, as reported earlier (page 217), there was a growing acceptance for the more learner-focused teaching approaches.

It was by means of a detail elaboration of the teaching steps by my students that I could identify or differentiate whether a teaching approach was content-focused or learner-focused. Originally, the Phase II students could not gave a detail teaching procedure. As time passed, I discovered that student teachers displayed an improvement on their teaching sequences in their journals (page 219). They gave detail teaching steps, the examples they would like to use and the relevant important points they would stress while teaching (page 219). By way of analysing the written entries, I confirmed that my students made improvement in their espoused teaching sequences and sustained their constructivist perspective in teaching.

To further confirm student teachers' learning in my methodology class, I studied the teaching performance of three outstanding students of the 2SC-98 class. In their actual teaching, the 2SC-98 case study subjects displayed a "teacher-talk, pupil-listen" approach (page 262). During the post-lesson discussion and during the end-of-module interview, the case students invariably expressed their intention to offer far more pupil activities than they had demonstrated in the classrooms. They felt that their actual performance was on the contrary because they lacked the relevant teaching experience (page 262). The behaviour of the pupils in class and the traditional teaching approaches imposed on them by their mentors were other factors influencing their classroom performance. My critical friend obtained similar results after she conducted a focus group meeting (in my absence) for the whole class of 2SC-98 students in the last session of my methodology lesson. However, overtime, I am sure my students could develop the necessary class management skills and implement their intended teaching sequences successfully.

From the above discussion, it is clear that my approach for teaching the Phase II cohort of student teachers sustained their original constructivist beliefs; meanwhile, new learning had been facilitated. In addition, my students learnt more in my classroom than in a typical methodology one in Hong Kong. They appeared to understand the role of their lecturer and their own role as students in the constructivist classroom in which they saw ample opportunities for working alone and in groups (pages 262-263). Their lecturer was a facilitator of learning, an expert in pedagogy and a mediator of conflicts and disputes. They themselves had to be proactive learners – they were helping one another in their learning by self-articulation and reflection, by providing viable teaching viewpoints, and by integrating knowledge of their peers and their lecturer into their own prior beliefs. They asserted that they enjoyed my lessons and were observed to do so (pages 262-263). They were also found to be participating actively and discussing rigorously, sometimes with no reservation, although they still showed respect for me and for their peers, probably intending to maintain harmony – a quality to be observed in the Chinese culture, as reported earlier (e.g., see Chapter Five, pages 246, 252: "The Creation of a Social Constructivist Learning Environment").

Thus, my Phase II students developed an attitude of inquiry and reflection in their own process of teaching. The vital aim of developing lifelong learners in (mathematics) teacher education seemed to have manifested in this cohort of student teachers. The constructivist-style learning environment created by me in the methodology class appeared to be an appropriate approach for student teachers taking mathematics as an elective in HKIEd. (Such an approach helps remedy the paucity of exemplar models for teaching (Asian) teachers, as reported by researchers such as Borko and Putnam (1995, p. 35), and Tillema (1997b, p. 283)).

Thus in answer to Research Question 2, the results of the study confirm that:

My constructivist model of teaching was appropriate to use with a class of first-year Chinese student teachers of mathematics at the junior secondary level (i.e., for pupils between 12 and 15). It sustained students' learner-focused beliefs in teaching mathematics, and developed in students an attitude of inquiry. Student teacher learning was actually facilitated.

QUESTION 3: THE CONSTRUCTIVIST LEARNING ENVIRONMENT

Can the constructivist approach also develop a social environment in the methodology classroom?

My Social Constructivist Model

It was my belief as well as my critical friend's viewpoint that not only are learners capable of developing their own theories of teaching, but that each learner actually constructs his or her own teaching approach. This implied that mathematics teaching approaches should not be prescribed to my student teachers; rather, student teachers should be allowed to develop their own approaches as they engage in various activities from which they try to make sense of the methods and explanations they see and/or hear from others (e.g., Korthagen & Kessels, 1999, p. 10).

Accordingly, in this study I tried to develop instructional activities that facilitated and fostered the construction of teaching approaches and beliefs. However, to overcome the time and resource constraints inherent in my methodology module, I only designed "artificial" teaching activities in which student teachers were asked to plan activities, restructure teaching sequences and pace the lessons during the methodology class meetings – there were no demonstrations of real teaching and application of constructed learning in the classroom context (see Chapter Two, pages 42-47). To determine if my students could see the relationships between mathematics topics and understand the general teaching and learning principles, I chose to observe the actual classroom teaching of three outstanding student teachers selected from the same class of methodology students (e.g., see Chapter Three, pages 86-88). I also discussed with this case study group their views about teaching mathematics, and conducted an interview at the end of the module to further clarify their teaching beliefs (e.g., see Chapter Three, pages 93-94).

As seen in Chapter Three (pages 101-108: "Phase II – My Teaching"), the instructional activities I organised were of three general types: (1) self-articulation and self-reflection, (2) small group activities and (3) lecturer-led (Phase I) or student-led (Phase II) whole-class discussion, all with occasional input from the lecturer. In a typical two-hour session in Phase II teaching (see pages 103-104), the first 20 minutes were devoted to self-articulation of how a topic common in junior secondary mathematics should be taught, and the last 20 minutes were allocated for student teachers to reflect on their earlier suggestions. In both cases, student teachers recorded their opinions and reflection in their journals. For the remaining time, 30 minutes were used for small-group discussion and 40 minutes for whole-class discussion, during which group leaders explained to Class-98 members their group's consensual teaching approaches.

Self-articulation on the teaching of a topic in junior secondary mathematics was intended to take care of the wide differences in student teachers' knowledge, experiences and goals (e.g., Korthagen & Kessels, 1999, p. 5; Loughran, 1996, p. 14). At first glance, this might appear to be a limitation, since I could not guarantee that all student teachers would think about a teaching task in the same way. However, it became an advantage in that it was a means to individualisation – each student teacher attempted to solve the teaching problem that made sense to him or her given his or her level of understanding and conceptual development. Thus, the introduction of a problem in teaching could ensure that my students found the activity meaningful and worthwhile. Furthermore, in this activity in the second phase, I provided my students with a special proforma to guide their self-articulation (as well as self-reflection) (e.g., see Chapter Three, page 104: "A Form for Self-Articulation and Reflection"). By so doing, I managed to help them to focus their discussion (and hence more efficiently use their time).

In Phase II, student teachers worked in the same group (each comprised of four to five members) during small-group discussions throughout the entire methodology module (e.g., see Chapter Three, page 105: "Group Discussion, Presentation and Class Discussion"). This arrangement allowed them to work collaboratively in developing both teaching sequences, examples for illustrations and important teaching points agreed upon by the group. In addition, the arrangement appeared to develop in them a sense of belonging to the group and hence friendship among members – a relationship much treasured by Chinese learners (e.g., Chan, 1999, p. 299; Gao, Ting Toomey, & Gudykunst, 1996, p. 291). I believed that once student teachers became acquainted, they would very likely overcome the worry of being humiliated in front of a group of friends or of embarrassing themselves. In this way they would express themselves more freely, converse more openly with one another and negotiate for consensus more willingly. During the group work, I circulated from one group to another, observing and encouraging student teacher discussions, and, when necessary, intervened in a discussion by asking questions and providing hints about how a problem might be solved (see Chapter Three, pages 80-85: "The Period Before Class Assessment"; see also Chapter Four, pages 175-176, 181-183; Chapter Five, pages 249-251: "Lecturer Intervention").

In the subsequent class discussion, student teachers from each group presented and explained their teaching approaches. I tried to assist student teachers clarify their explanations and verbalise their thinking, and actively encouraged all of them to defend their own teaching ideas, respect others' ideas and offer constructive suggestions. I did not tell my students if their solutions were appropriate or not, but motivated all of them to agree, to disagree and to reflect on the suggested approaches – because according to von Glasersfeld (1995, p. 15) the recognition of the inadequacy in one's approach often provides the incentive for change. When student teachers disagreed, student teachers worked as a whole to resolve the disagreement and attempted to reach a consensus. At the conclusion of the class discussion, I asked my students to reflect on their teaching ideas again in their journals – students were provided the freedom to choose the best teaching approach. Otherwise, student teachers would lose the incentive to search for a "better" solution (von Glasersfeld, 1995, p. 15). Afterwards, I collected the journals, dated them, commented on them and returned them in the next session. (See Chapter Three, pages 104-106: "Phase II – My Teaching"; see also pages 80-85: "Period Before Class Assessment".)

My attitude was crucial to the development of a problem-solving atmosphere in the tutorial room. In order for my students to share their teaching ideas, I believed that they should actively attempt to communicate with one another and with me, the lecturer. Successful communication requires the negotiation of meanings and depends on all members of the Class expressing genuine respect and support for one another's ideas (Bauersfeld, 1995; Lerman, 1998). This means that every time a student teacher commented on a point raised in the discussion, I asked all members of the Class-98 to agree that for any student teacher who responded, his or her description would be considered meaningful. Meanwhile, I assured them that I would help every one in the Class-98 to clarify their interpretation of teaching ideas. Following this, the entire Class-98 members were asked to compare and contrast the assertions claimed in the discussions in terms of their own cognitive framework. In this way, I led my students to realise that expressing themselves in class was not dangerous, contrary to a common belief among Chinese learners (e.g., Chan, 1999, pp. 298-299; Pratt, Kelly, & Wong, 1999, p. 255). Furthermore, the environment also allowed them to understand that the authority in teaching did not reside solely with me, the lecturer, but with both the lecturer and the Class-98 as an intellectual community. The authentic creation of such a non-threatening environment in which Chinese students and myself collaborated to solve a teaching problem was witnessed by my critical friend, my students and myself and is described more fully in the following subsection.

The Created Learning Environment

Findings about the classroom environment obtained from various sources in both Phase I and Phase II were positive – supporting the idea that a social constructivist learning environment had been successfully created (see foregoing sections, pages 260-262 and 266). In this classroom, student teachers were expected to construct and reconstruct their own understandings about mathematics teaching by self-articulating and later self-reflecting on a problem concerning mathematics teaching that had been posed at the beginning of a methodology session. The problem became a central topic for discussion in small groups and in the whole class in between the personal construction processes (page 268).

Student teachers expressed the view that they had learning experiences in my methodology classroom which they had never experienced at HKIEd before (see the preceding section, pages 262-263). The 2SC-98 students in particular remarked that they enjoyed my lessons – some even clapped their hands at the end of some of the sessions (Appendix 5A, Thursday, 4/2/1999, page 404; Thursday, 1/4/1999, page 412). To them, learning seemed to be fun, humorous and collaborative. My critical colleague and I observed that students were very well-motivated, participating actively in class and in group discussion (see the preceding section, page 263). They worked as a group, stimulating and motivating one another and developing an interest in learning together. Apparently, they were satisfied with the methodology sessions and with the whole learning process.

Both the 2SC-98 students and my critical friend found that there were plenty of opportunities for student teachers to communicate with one another, for instance, in group and class discussion, student teachers agreed that there were opportunities to verbalise their thinking, explain or justify their ideas and ask for clarifications (see the preceding sections, pages 262-263; see also pages 266, 269-271). Attempts to resolve conflicts led to opportunities for student teachers to reconceptualise the teaching approaches and to extend their conceptual framework to incorporate alternative solutions (e.g., Nicol, 1997, p. 97). More importantly, they did not need to be afraid of making any mistakes or misinterpretations in their assertions, because nothing could be wrong – only agreed upon or disputed. Showing disrespect and losing face in front of their peers could be reduced to a minimum, because everyone was treated equally (see the foregoing sections, pages 266, 269-271). This allowed them to have lively and effective interaction with me, even though, as a lecturer, I would usually be considered a respected elder in the Chinese tradition (e.g., Pratt et al., 1999, pp. 246-247).

Student teachers of the two cohorts, however, indicated that there were fewer opportunities for (1) learning about methodology in mathematics teaching, (2) learning about their pupils' learning and (3) learning to learn when compared to the abundant opportunities for learning to communicate and to speak out (see Chapter Five, pages 253-256: "Learning About Secondary Pupils' Learning (LP)", "Learning About Methodology (LM)" and "Learning To Learn (LL)"). Apparently, student teachers considered themselves less well equipped with both the necessary teaching techniques in mathematics classrooms and the psychology of mathematics learning, particularly in relation to junior secondary pupils (see also their unaltered indecision about the nature of mathematics, the content of mathematics and how the content can be presented in the preceding section, pages 260-261). They could not control their own learning and assessment.

As mentioned in Chapters Four and Five (respectively pages 162-163 and 255-256), the syllabus for my methodology module was rigid, and the student teachers could not decide what they would like to learn and how they could be assessed. Within the two-credit-point-hour, assessment tasks had already been prescribed, and for validation and quality assurance purposes, the procedures had to be strictly followed. The only flexibility was perhaps in the choice of members in a discussion group.

Within the time constraint (30 hours for lectures, directed study and assessment), the best teaching (and assessment) strategy employed was to let my students discover the basic principles of mathematics teaching. For instance, my students seemed to understand that junior secondary pupils actually possess their own understandings about mathematics before they come into the classroom (see the preceding section, pages 260-261). During the lessons, these pupils constructed their own distinct mathematical knowledge – no two pupils constructed the same understanding. The mathematics teacher's role is to create a learning environment and to plan ample opportunities for knowledge construction (see the preceding section, pages 260, 262). Over time, student teachers showed improvement in planning their own lessons – by displaying in their journals an awareness in structuring the lessons, in adjusting the pace, in organising the various learning activities for their pupils, in emphasising the relevant important teaching points and in selecting related examples and exercises for pupil interactions (see the preceding section, page 262). In this aspect, student teachers seemingly had acquired fundamental knowledge about teaching mathematics – learner-focused belief that was stabilised by their immersion in the lively and non-judgemental environment created in my methodology classroom (see the preceding section, pages 264-267).

I believed that confirmation of learning should not rely only on summative evaluation – for instance, the end-of-module CLE questionnaire which investigated, in addition to the creation of a constructivist learning environment, the existence of opportunities for learning the various teaching methodologies and principles. It was undoubtedly important to know how much one has learned at the end of a methodology module, but the process of learning was also imperative. My students seemed to have displayed learning during the class meetings. Often, we (my critical friend and myself) observed that the students appeared to have developed the awareness of creating opportunities for personal and social construction of mathematical knowledge (see the previous paragraph). They found my lessons interesting and participated actively in the various activities in which discussions abounded (see pages 271-272). They remarked that my lessons were useful; they could develop confidence in teaching and speaking in front of a class of people (see pages 271-272). In particular, the 2SC-98 cohort of students could apply, though not too successfully, what they learnt in the sessions (see the preceding section, pages 264-267). Last but not least, the 2SC-98 students learnt that the main objective of mathematics teacher education was to develop a lifelong learner – someone who could reflect on personal teaching experiences and develop teaching theories suitable for classroom use (see the preceding section, pages 264-267).

Thus in answer to Research Question 3, the results of the study confirm that:

My constructivist model of teaching developed a social environment in the methodology classroom. There were ample opportunities for students to articulate their teaching ideas, to interact with their peers and with me, and to construct and refine their teaching methodologies. Student teachers' understanding of their role as learners and my role as a facilitator and mediator of learning was a clear indication of the creation of a social constructivist learning environment.

QUESTION 4: IMPLICATIONS FOR MATHEMATICS TEACHER EDUCATION

What are the implications of the study regarding teaching and learning for Chinese teachers of mathematics?

In addressing this question I found it necessary to consider the (successful) result of my model of teaching first-year Chinese student mathematics teachers in a methodology classroom; the practical significance of the study in my workplace; the study's contribution to the literature regarding mathematics teacher education, and the limitations of the study. The first part of this section begins with the significance of the present study in mathematics teacher education and the second part deals with its limitations. The implications of the study for teaching and learning and areas for future research were discussed in both parts.

Significance of the Study

Mathematics Teacher Education in Hong Kong

From my past experiences in mathematics teacher education, Hong Kong student teachers seemed to possess teacher-centred beliefs which governed the choice of their teaching approaches and shaped their classroom teaching performance. In their field work, student teachers (including the selected outstanding students of the two cohorts in this study), though committed, strove to pass onto their pupils as much mathematical knowledge as possible, leaving very little opportunities for pupils to carry out individual and group work. Even if time was set aside for pupil-pupil and teacher-pupil interactions, the time was usually insufficient for knowledge construction – which I regarded as an extended process requiring peer discussion, expert input and self-reflection. In the (two years of) initial teacher education at HKIEd I found that I was not totally successful in changing my students' beliefs from a more conservative transmission approach to more social-interactive ones. There were many factors affecting my students' practices in classrooms.

The present study, however, did not aim to confirm or disprove such strongly held beliefs about teaching mathematics. It was based on the assumption that my students might possess some beliefs about teaching mathematics that might not be easily changed.

With the growing acceptance that (mathematics) knowledge is socially and personally constructed by the pupils themselves rather than received intact from the mathematics teacher (e.g., Bauersfeld, 1995, p. 140), future teachers necessarily have to understand this important concept in learning. A consequence of this approach is that teaching and learning in mathematics classrooms needs to be more pupil-centred – with abundant opportunities for pupils to encounter mathematics problems, to investigate and test hypotheses, to express and discuss personal viewpoints in ordinary language and in the language of mathematics, and to draw conclusions (with the assistance of the teacher as an expert in mathematics) where necessary. The learning process is stressed, in addition to the product of learning. This required my preservice student teachers to accept a new type of mathematics classroom environment – an aspect which, according to my critical friend and to me, appeared quite successful in this study (e.g., see the preceding section, pages 273-274). However, it also requires new teaching approaches to be used by mathematics teacher educators. How this could be achieved requires further investigation.

The Model of Teaching in Mathematics Teacher Education

I studied the theory of social constructivism while I was pursuing my masters degree at Curtin University. Though the theory did not provide a concrete model for teaching and learning, it assisted me to explain why student teachers held firm beliefs about teaching, and it stimulated me to re-examine my own teaching approach. Constructivism acknowledges learners' prior entrenched beliefs – in the case of this study, these are the beliefs about teaching held by my student teachers. Such beliefs probably developed unconsciously during their experiences of mathematics learning in their previous years of schooling, and later manifested in their conversations and classroom teaching in their teacher training (e.g., Borko & Putnam, 1995, p. 59; Tillema, 1997a, pp. 209-210). I concur with Bauersfeld (1992, p. 2; 1995, pp. 137-144) that these firm beliefs could be changed if student teachers could be led to identify their own viewpoints, to realise – through discourse – that these teaching ideas do not conform with those of their peers and their lecturer, and that they are not viable. The process would then lead to reconstruction and reframing of teachers' own teaching beliefs.

Reflection on my past teaching approach – lecturer talking and student listening in order to learn – led me to rethink the significance of class interactions implied by the theory of social constructivism. It seemed that if I transformed my teaching orientation to a more learner-centred and interactive approach, my student learning would be enhanced. Thus, based on what I have learnt from my academic study and my teaching experiences, I designed a social constructivist model of teaching for my methodology class. My students were given ample opportunities to speak out and to communicate with their peers and with me, and hence to learn through social interaction.

The model of teaching in my methodology class was described in Chapter Two (pages 40-47) and a flowchart was produced to represent the model (Figure 2.1, page 43). The details of the implementation procedures of the two phases were depicted in both the chapter on methodology (Chapter Three, pages 76-86, 101-108) and the chapters which present and discuss the results (Chapters Four, pages 175-183 and Five, pages 238-256) – some of the highlights are also reiterated in the earlier part of this chapter. To restate my teaching sequence (e.g., see Figure 2.1 on page 43), the process was as follows: A problem in teaching junior secondary mathematics was posed to student mathematics teachers who were asked to elaborate their own approaches to the solution; to discuss these ideas among themselves in small groups and then to present their agreed views to the class of students. This was followed by the students in the class commenting on each group's suggestions, with the lecturer acting as a mediator and an expert. Before and after the group and class discussion, student teachers had to reproduce their own ideas in their journals about how the problem concerning the teaching of a specific mathematics topic could be solved. The results of the study showed that the model which I designed was appropriate for my student teachers (see pages 264-267: "Question 2: The Efficacy of the Approach"). Though I do not intend to generalise the findings of the study, I consider that my model does provide an additional teaching approach – probably new to many of my colleagues – that is appropriate for methodology classes in HKIEd.

There is a paucity of literature about the employment of social constructivism as a learning theory in mathematics teacher education (Bauersfeld, 1995, p. 137; Gale, 1995, p. xii). My model of teaching, designed on the basis of the theory, adds to the literature on constructivism in junior secondary mathematics teacher education, particularly teacher education in a Chinese setting. As any teaching model should, my design took into consideration the characteristics of the students I have been teaching. My students are Chinese learners who are by nature modest, silent and obedient in class, possessing a high motivation for educational achievement (Biggs, 1996, p. 150; Chan, 1999, p. 296). Hong Kong Chinese students, according to Biggs and Watkins (1996, p. 278), are not used to writing and expressing their own opinions during class. Thus, more guidance on self-articulation and self-reflection was provided to them, as described in the second phase implementation. This was evident in the worksheet containing three columns: (1) teaching sequence and activities, (2) examples and exercises and (3) important points to stress in the teaching process (see Appendix 3G, page 328).

I reminded myself continually that I had to be an encourager – one who made every effort to motivate and stimulate my students to put forward their ideas clearly in writing, to air their opinions freely, to respect others' ideas, to scrutinise viewpoints and to integrate the plausible ideas into their own cognitive structures. Bauersfeld (1995, p. 152) maintained that viable knowledge construction depends not only on the qualities of the social interactions, but also on the participants' active engagement in the social practice. Chinese learners are considered humble people who do not like to display their knowledge in front of the class (e.g., Hau & Salili, 1996, p. 132), and thus encouragement was a must.

Student teachers' withdrawn behaviour might not be due to self-effacement, but could be caused by their fear of humiliation as a result of not knowing how to respond in front of the class (Stevenson & Lee, 1996, p. 134). I therefore also acted as a protector of my students in order to save them from losing face. I had to be on the alert for signs of discontent or disputes among the student teachers and to act immediately as a mediator in cases of disagreement and conflicts. I also tried to be careful in providing remarks. I tried not to push my students too far through commenting on any inadequacies in their teaching approaches, because this may have brought shame on the student teachers themselves; rather, I encouraged my students to adapt other students' views or my contentions and to incorporate these viewpoints into their own ideas about mathematics teaching.

Where necessary and at an appropriate time during the lesson, I tried to comment on students' ideas on teaching – because Chinese learners probably expect to be taught – but with discretion. I did the same in the journals collected at the end of a session. My prompt input served as evidence of my lecture preparation and planning. Minimal input from the lecturer would cause Chinese learners to be unsatisfied with lessons. Furthermore, student teachers' learning in my constructivist model also required relevant and proper expert knowledge (as in Lerman's (1998) interpretation of Vygotsky, pp. 337-339).

My actions in implementing the constructivist approach probably deviate from those reported by many western researchers (e.g., Barker, Child, Gallois, Jones, & Callan, 1991; Jin & Cortazzi, 1998; Pratt et al., 1999; Sue & Okazaki, 1990; S. Winter, 1995). The adjustments that I have made, however, are necessary in the Chinese culture if we want to actualise constructed learning in our classrooms in a way that student teachers find fruitful and enjoyable.

Undoubtedly the constructivist thrust of curriculum change in Hong Kong has been uncritically accepted to a certain degree. Worldwide research on this theory of learning has, however, been so positive that it cannot be ignored by non-western countries. What is needed in Hong Kong and in other non-western countries are original studies, such as my study, and the replication of successful western research studies to determine the efficacy of this approach to curriculum change in South East Asian countries. In this regard, I consider this aspect of my research to be perhaps its most significant contribution to the literature.

Action Research

In this thesis, the efficacy of the new model of teaching was studied through my conduct of an action research study. Action research, which has become increasingly recognised in mathematics (teacher) education (e.g., M. Brown, 1998, p. 263), particularly suited my teaching purpose. By definition, action research is research in one's own classroom in order to improve one's present teaching practices (e.g., Elliott, 1997, pp. 18-19). Not only could I determine the appropriateness of a new model of teaching by way of action research, I could also enhance my classroom performance and professional knowledge. I now have an additional approach to teaching in my methodology class. I have a better understanding of my students in terms of their beliefs about mathematics teaching and their perspectives about mathematics and its nature. I find that I am now more conversant with social, interpersonal and communicative skills when facing my students. I am more open, flexible and confident in conducting discussions, in providing comments and in interacting with my students.

It is hoped that my newly designed model of teaching (e.g., see page 277 in the preceding subsection) will be adopted or adapted for use by other members of the Department of Mathematics or by colleagues in HKIEd, and that my learning experience will be shared by others in my workplace and by (mathematics) teacher educators elsewhere.

As a result of undertaking action research in this study, I have now enhanced my understanding of this research methodology in terms of its rationale, design and techniques. This single-site investigation has now been proved to be workable and manageable. Throughout the process of action research, I developed myself into a better reflective practitioner – I am now more aware of my own practices, and am more able to reflect on my actions and to change those practices when appropriate. I now have full confidence in my ability to employ action research in future investigations of my own practices in my search for improvement. Moreover, the viability of action research in determining the effectiveness of a teaching model in mathematics teacher education not only leads to professional self-improvement, but is also an effective means of adding to the relatively rare higher education literature in this area (e.g., Altrichter, 1997, p. 33; Cooke, 1998, p. 3; Tzur, 2001, p. 259).

Data Collection

The Beliefs About Teaching Mathematics questionnaire (Appendix 3C, page 320) was useful in eliciting the first-year student teachers' beliefs about teaching – the social constructivist viewpoint. The single overall average score served as an indication of each student teacher's teaching orientation – whether it was social-interaction or content-performance, and a study of the scores of individual belief item further allowed me to probe more deeply into student teachers' ideas about the mathematics teacher's role, the nature of mathematics teaching and the nature of the subject discipline itself (Van Zoest et al., 1994, p. 47). I was therefore able to identify several inadequacies in student teachers' instruction and thereby offer subsequent guidance. This questionnaire is highly recommended for future use.

The Constructivist Learning Environment Survey (Appendix 3F, pages 325-327), too, allowed me to investigate whether a social constructivist learning environment had been genuinely created and is therefore also highly commended. The preliminary categorisation of item responses facilitated the calculation of each category's mean score and revealed an authentic learning environment in my methodology classroom. The survey allowed me to tally the number of opportunities for learning about teaching methodologies and junior secondary pupils' learning, and of learning activities which catered for speaking out, communication and learning to learn. This enabled me to understand the adequacy or inadequacy of these opportunities of group and class discourse, and of developing both cognition and metacognition.

The quantitative data was complemented by review and interpretation of the writings in student teachers' journals (e.g., Patton, 1990, p. 169). The student teachers were required to articulate their teaching sequences for a simulated teaching episode. Thus, opinions about teaching a particular topic, in particular the choice of teaching sequences, of activities, and of examples and exercises, were displayed on paper. I believed that the choice of any approach by my students would reflect the specific teaching orientation held by each of them. Student teachers not only reviewed their prior teaching beliefs by way of writing, they also started to think about how to reorganise and rework their knowledge into forms appropriate for classroom use.

The actual implementation of my students' constructed teaching ideas in teaching a mathematics class was investigated by observing (in each phase) three selected outstanding students' (the "Case") lessons and by discussing their planned teaching ideas with them (Patton, 1990, p. 170). Both the lesson observations and post-lesson discussions facilitated my understanding about these student teachers' behaviours in the classrooms and their thinking about mathematics learning – pupils in schools affected their initial plans for teaching, and so did the real teaching situation. The difficulties encountered in the actual teaching by ordinary student teachers, however, might not be exemplified in this part of the study. (The limitation of the study with respect to the employment of outstanding student teachers will be discussed later in the subsection "Student Teachers' Data" under "Limitations of the Present Study", pages 289-291.) Further research studies into factors affecting practising teachers' attitudes and behaviours in the field experience is needed.

At the end of the methodology module, the ten interview questions, adapted from Van Zoest et al. (1994, p. 44) and used to verify the selected outstanding student teachers' beliefs about mathematics teaching, proved their effectiveness in both cross-checking the Case students' ideas on teaching and allowing me to access more information about my students' thinking. For instance, the unstable beliefs about teaching, the inexperience in handling a mathematics class, and the possible factors affecting the teaching approaches before, during and after the actual classroom teaching were all revealed during interviews and provided new evidence of the instability of the student teachers' ideas that could not possibly have been extracted from the quantitative data.

Obviously, personal bias and misinformation could also occur in the data and evidence obtained by me – an insider doing research on my own teaching – and hence the possibility existed that my findings could be untrustworthy. The employment of a critical friend in my department to provide support and expert feedback was thus significant. The critical friend's expertise and her understanding and interpretation of the various activities observed in my class provided opportunity for confirmation or contradiction of the interpretations based on student teachers' data and the data provided by me, the action researcher. For instance, the focus group meeting conducted in Phase II with the student teachers in my absence imposed little pressure on my students, and results obtained in the meeting could be regarded as a genuine reflection of my constructivist-style classroom and of my students' learning. The interpretation provided by my critical friend thus provided an independent picture of what was going on in my classroom. The colleague observer's integrity and her "third opinion" are crucial in action research (and interpretive research) (e.g., Guba & Lincoln, 1989, p. 237) – her reports furnish strong evidence that is trustworthy, and in my case, provide affirmation that I was really creating the learning environment espoused in my teaching model.

Other Considerations

The attitude of my student teachers was important in the implementation of my model of teaching. Equally, my positive attitude in creating an atmosphere of trust and discourse, my own constructivist beliefs, and my confidence in my Chinese students' motivation to learn, their willingness to talk and to express themselves, and their ability to improve their learning were all vital. Without mutual trust and respect among all of us – students and lecturer alike – learning could not occur, irrespective of the type of learning activities planned for the student teachers. The experiences gained through teaching and educating teachers should be shared with other teacher educators – for instance, the difficulties confronting a facilitator and a mediator of student teachers' learning when Chinese students rejected the created learning environment and refused to cooperate; the occasional joy and frustration encountered in interacting with student teachers in the tutorial room and in field experience; and the pressure in working in an institution undergoing rapid changes. Diaries and life histories of teacher educators seem lacking (e.g., Cooke, 1998, p. 3; John, 1996, p. 119), and perhaps more encouragement could be given to the reporting of teaching episodes in teacher education. A supportive environment is required in teacher education, and one of the ways of achieving this is by way of documenting one's teaching events and feelings.

The language used in the module, I perceived, was also paramount. The use of the mother language possibly facilitated an easy and non-threatening flow of dialogue. More genuine and accurate responses to the questionnaires could thus be collected when the questions and items were all in Chinese. Communication among student teachers and with me were more expeditious when the mother language was used. Furthermore, the student teachers in my study were all expected to teach mathematics using Chinese as the medium of instruction. Nevertheless, conjecture that the mother language facilitates learning is a current controversial issue in Hong Kong, and its effectiveness in enhancing learning has yet to be determined. As regards the effect of language in mathematics learning, it has already been well documented that learning is hampered in the absence of language familiar to the pupils (Costello, 1991, p. 180).

Guided teaching practice in schools appeared to change student teachers' beliefs. The three outstanding students (the case study subjects) in each phase of my study seemingly displayed traditional teaching approaches after their return from their teaching practice, as reflected in their post-lesson discussions and in the post-module interviews (e.g., see the preceding section: "Question 1: Beliefs About Teaching Mathematics", page 262). Observations of the Case students' classroom teaching and the after-lesson discussions signalled that the school environment had prompted them to change their inward social constructivist belief in order to survive the teaching practice. Thus, the choice of the mentors in schools, the school culture and the pupils all appeared to affect student teachers' original orientation to teaching, at least in regard to their remarks about teaching mathematics and their outward classroom performance. Again, research in this area would seem to be necessary.

If immersion in a school for field experience has a significant effect on a student teacher's beliefs about teaching mathematics, then perhaps a sustained constructivist environment created for my students in every module they pursued in HKIEd might have an influence on their initial teaching beliefs (Van Zoest et al., 1994, p. 52). This implies that if HKIEd adopts a whole-institute social constructivist teaching approach, then student teachers may benefit from such a learning environment and develop a more learner-focused perspective about (mathematics) teaching in future. Much work remains to be carried out before the whole institute – academic staff and student teachers alike – will accept such an approach. Research studies will then need to be conducted to determine the efficacy of such an innovative idea for the education of future teachers.

The demands and complexities of (mathematics) teachers' work have been well documented, (although it is undeniable that routine and repetition also exist in the work). The development of a stable learner-centred orientation to teaching among prospective teachers in HKIEd involves professional thinking of the deepest and most demanding kind. As the main teacher education provider in Hong Kong, HKIEd should provide a well-structured, supportive professional-development environment in order that our prospective teachers are able to restructure and reshape their practices and develop the ability to learn how to learn in their initial teacher education. However, this is probably insufficient, as the data from the Case trainees clearly indicated that their practices in the schools were affected by the schools' other teachers. This suggests the need for the provision of equally well-structured and supportive inservice teacher education programmes to continually support our graduates and to guide them to become life-long learners.

Overall, the evidence of my study indicates that my constructivist-based model of teaching was appropriate for use in the methodology class of first-year Chinese student mathematics teachers. The sets of data obtained by various methods from both the students and from the case study subjects generally corroborated each another and together served as grounds for the successful implementation of my teaching model. There are, however, limitations to my present study; much more remains to be done by myself and by HKIEd if any significant contribution to teacher education in general and to mathematics teacher education in particular is to be realised.

The next subsection focuses on the limitations of the study.

Limitations of the Present Study

Views of HKIEd Colleagues

The current pedagogy in mathematics teacher education in HKIEd may pose a limitation to the claimed success of my constructivist model of teaching in a methodology class. As noted at the very outset (Chapter One, pages 2-3), colleagues in methodology classes at HKIEd have been focusing on the transmission of knowledge to students in a "recipe" approach, on the assumption that student teachers will develop the repertoire of skills required in teaching school mathematics in the shortest possible period of time. As assessment also demands a reproduction of the procedures of teaching (which may include those employing the theory of constructivism), it appears that successful replication of the "taught" knowledge proves that there has been effective learning on the part of student teachers, and hence effective teaching in the methodology courses. From this perspective, my constructivist approach may be considered ineffective, because it places a greater emphasis on the process of learning than on its products. My colleagues could argue that too much time would be spent on student teacher interactions, and even worse, they may be sceptical about the kind of pedagogical knowledge constructed by my student teachers during my class –

for example, they may doubt whether my students will be able to develop the necessary teaching skills.

The pervasiveness of the teaching-by-transmission method, with its stress on the product, rather than the process, of learning – which had been my own practice previously and is my colleagues' present belief – may be one of the reasons that my graduates preferred (and my student teachers in the Cases reverted back to) the use of the traditional transmission approaches. They were taught in the same way at HKIEd!

Furthermore, although I could not guarantee that my student teachers had constructed the intended pedagogical knowledge, I certainly led them through an enjoyable, open and interactive learning process (see the preceding section "Question 1: Beliefs About Teaching Mathematics", pages 262-263). It is this process in itself which many mathematics educators may consider valuable for learning.

At the end of my lessons, my students indeed developed beliefs about teaching mathematics (see the preceding section "Question 2: The Efficacy of the Approach", pages 264-267); for instance, they showed that they could plan and provide opportunities for pupils to construct mathematical knowledge. They also began to query the feasibility of the direct instruction method and the amount of content to teach their pupils. Adopting specific teaching methods to suit a particular topic, however, might be too difficult for my inexperienced students to develop within the short time span in each session and in the total of 30 hours of contact for the whole methodology module. (Moreover, it is probably unrealistic to try to develop sophisticated methods of mathematics teaching in my students during the four weeks' teaching practice in the first year of study.) Rather, my students showed that they understood the role of both the lecturer and the students attending the methodology class (see the preceding section "Question 2: The Efficacy of the Approach", page 266). They claimed that they should try to develop their own theories of learning by integrating the teaching ideas that emerged in the class setting with their own beliefs, with the assistance of their peers and the lecturer via active group and class discussion. They valued the opportunities for learning from one another and respected their own constructed beliefs as well as others' ideas about teaching.

It is to be expected there are limitations in my study of student teachers' learning. In retrospect, my model may be successful in the specific groups of 2SC-97 and 2SC-98 Chinese learners, but it may not be so for other classes. There were insufficient opportunities for my students to describe their belief change processes – that is, their learning processes. Since the theory of constructivism advocates that learners construct their personal knowledge during the process of perturbation, defence and negotiation, I could have asked my students to express their feelings about the "discomfort" confronting them and their inner struggle as they wrestled with new beliefs about teaching. This may have provided further verification of my constructivist teaching model.

Time and Resources

The 30 contact hours for my methodology class (as assigned by my institute) may have been too short for knowledge construction and change of beliefs to take place. The actual time allocated for my students to articulate their beliefs, to have their ideas exposed and commented on, and to reorganise their ideas during the post-discussion self-reflection was so short that it may have limited their ability to manifest any meaningful change in their approach to teaching.

Furthermore, I could not, because of my workload, observe how all of my students applied their constructed knowledge in their actual teaching. Although they were found to possess an inwardly social constructivist orientation to teaching mathematics (e.g., see the preceding section "Question 1: Beliefs About Teaching Mathematics", pages 260-261), my claim that immersing my students in the constructivist learning environment that I had created would reinforce their learner-focused belief might not be totally convincing. It is possible that some student teachers were unaffected. Alternatively, my students might have been influenced by other learning environments, for instance, the common practice in HKIEd, the schools where they were placed for field experience, and by other unknown factors during the implementation of my study.

Student Teachers' Data

I learned about my student teachers' beliefs through their responses to quantitative measurements as well as to qualitative ones, and all of these, except in the case of the three outstanding students in each phase, were in written form. A number of different scenarios may have affected the authenticity of the data:

- Student teachers possessed certain teaching beliefs, and at the same time were able to reflect them clearly and accurately in the questionnaires and across their writings.
- Student teachers maintained certain beliefs, but they could not express them clearly in writing because of their lack of language skills or because of the difficulties in articulating their beliefs.
- Student teachers did not possess the beliefs, but might pretend to have them and reflect them in their writings and in their responses to the questionnaires.
- For reasons unknown, student teachers refused to complete the questionnaires and the journals and hence no data could be obtained.
- Lacking discussion and negotiation skills, student teachers and I could not come to some genuine consensual ideas about teaching; ideas might be biased by those who dominated the discussions.

While the reliability of the questionnaire may be suspect, as in any research studies, the researcher – in this case, myself – had to trust the integrity of the participants as well as to train the student teachers in their discussion and negotiation skills. Furthermore, others may query my own skills in extracting data from my students, for instance, skills in conducting an interview (the use of questioning, prompting and probing), in lesson observation and in discussing with student teachers. These are the techniques required of all qualitative researchers. In this study, great care was taken to ensure an accurate interpretation of data and, as an "insider researcher", I had the privilege to know my students quite well, which actually facilitated my understanding and interpretation of their writings. Data collecting, understanding, presenting and explaining findings, admittedly, require training and practice.

To obtain reliable data and at the same time overcome time and resource constraints, the literature suggests that I can study a smaller number of student teachers in greater depth (e.g., Guba & Lincoln, 1989, p. 239; Patton, 1990, p. 170); for instance, in my situation, I chose a set of three outstanding student teachers distinguished by their mathematics results in the first semester (the "Case"). The intention was to obtain generalisations about the characteristics of the whole class of student teachers by probing into a representative few. However, it is interesting to note that the Phase II Case students exhibited a more teacher-centred orientation than the average class belief (see "Case-98 Outcomes" in Chapter Five, page 220). This could mean that the Case study subjects were not representatives of the whole class of students in my study, and implies that the full range of students' perspectives needed to be taken into consideration. I would therefore recommend in future that if time and resources permit, in addition to choosing a Case at the beginning of the study, student teachers who hold contrary beliefs (dissident students) should be identified during the implementation process. In this way, widely differing attitudes and classroom learning perspectives could be obtained, in order to cast a more plausible picture of student teachers' teaching beliefs and of my constructivist classroom.

The employment of one of my colleagues, who is an expert in mathematics education and who has an adequate knowledge of the context of my workplace, to observe my lesson and to provide a "third" opinion also increased the trustworthiness of my interpretations (e.g., Guba & Lincoln, 1989, p. 237). After Phase I, my colleague observer trusted her observation about my created learning environment, but queried if she could obtain a better picture of my students' beliefs and learning in class. In Phase II, she suggested and conducted, in my absence, the focus group meeting as a way of gaining a clearer understanding of my students' beliefs from her perspective.

The foregoing procedures of identifying dissident student teachers and having a colleague conduct focus group meetings reflect the flexibility of action research – I can improve my practice and the plausibility of my findings at any time that I consider appropriate.

The Rigour of Action Research as a Methodology

Action research, for some, is not rigorous research per se (Wiliam, 1998, p. 12). The single-site investigation which involves a small sample of student teachers in my study invites criticisms regarding its validity, reliability, generalisability and objectivity. In this framework, findings obtained from only a small sample of about 20 student teachers could be considered unrepresentative. Variation of teaching beliefs among the student teachers existed (e.g., see the preceding section "Question 1: Beliefs About Teaching Mathematics", pages 260-264). The Case students in Phase II were also found to have beliefs rather different from those of the Class-98 students (see the preceding paragraph on page 290), and hence it could not be representative of the whole class of 20 students. Findings were obtained which were beyond my expectations. I made no presumptions before I embarked on my study – I allowed the findings to emerge. In other words, for some, the representivity of the research is problematic.

Exact replication of the procedure of teaching and of action research might be rather difficult, irrespective of my effort in describing and recording very carefully my research study. The structure of HKIEd, the methodology module and the characteristics of the Chinese student mathematics teachers in my class might be different from those of teacher education institutions elsewhere; different participants may have different interpretations and understandings of events –

they are dynamic and change continually. Hence, it is unlikely that anyone could obtain the same or similar findings to mine. From some perspectives, the reliability of my results and the generalisations I draw from them could appear implausible.

To try to transcend the limitations of action research described in the foregoing paragraphs and elsewhere in Chapters Two (see "Rigorous and Valid Form of Inquiry", pages 61-63) and Three (see "Maximising Rigour in the Study", pages 71-76), I endeavoured to employ Guba and Lincoln's (1989) criteria to justify my research. Instead of rejecting the positivist rigour of validity, reliability, generalisability and objectivity as unworkable, Guba and Lincoln tried to understand and adjust the original standards of quantitative research and apply them to qualitative studies which require personal construction of understanding, judicious interpretation and manipulation of data obtained by various methods. Their criteria were reviewed in Chapter Three (pages 71-76) and are important to briefly mention in my conclusion.

The criterion of (internal) validity to judge the trustworthiness of an inquiry was replaced by the credibility criterion (Guba & Lincoln, 1989, pp. 236-237). Instead of establishing the truth of the results, isomorphisms among emergent findings in my research study were matched. Observations and other data obtained were analysed, and particular attention had been paid to contradictory viewpoints – for example, identifying dissident students and addressing their feedback to guarantee an appropriate match. A "disinterested peer" (Guba & Lincoln, 1989, p. 237), in my case, one of my colleagues in the Department of Mathematics, was employed to provide support to me, both morally and in actual practice.

The other issues of positivist criteria were handled accordingly. Replication of research procedures (reliability), generalisability and objectivity were dealt with by creating the parallel criteria of dependability, transferability and confirmability. A dense description of my study, for instance, the time, place, context, research procedures, findings and explanations of changes, which were requirements of the criteria of dependability (of my logical research processes) and transferability (of my judgements to new research situations), was documented. The confirmability criterion – a careful recording and documentation of processes and findings (for example in computer files) for easy retrieval and inspection by outside reviewers – was also observed.

Overall, there are limitations to my action research study. Even at the conceptual level, mathematics teacher educators or researchers possessing a view other than the constructivist's would find the results of my study problematic. However, the pedagogy in mathematics teacher education should continually be explored and negotiated. Time and resource constraints often pose problems in inquiry that demand extensive involvement and engagement of the researcher in the classroom. The authenticity of the data obtained is another major concern in action research. Finally, I suggest that the rigour and limitations of action research, which often invite criticisms by some, could be enhanced and surmounted by employing Guba and Lincoln's parallel criteria of credibility (validity), transferability (generalisability), dependability (reliability) and confirmability (objectivity).

Table 6.1 summarises the significance and implications of my present study.

Thus in answer to Research Question 4, the results of the study confirm that:

My constructivist-based model of teaching was a new approach to teaching appropriate for use in my methodology class of first-year Chinese student mathematics teachers. I believed that the successful implementation of my approach to teaching depended on my belief as well as my students' belief (whether acquired during the methodology period or the belief had already been possessed before the commencement of the methodology class) that teaching methodology is constructed and socially negotiated; and undoubtedly, my students enjoyed the learning process. In this respect, the viability of my model in other classes of Chinese learners is controversial.

Table 6.1
A Summary of the Significance and Implications of the Present Study

Significance	Implications
Mathematics teacher education	
An appropriate new teaching approach or an additional one.	Revisit goals of mathematics teacher education and mathematics teaching.
	Positive attitude and skills of the lecturer and student teachers vital. Train student teachers and lecturers.
	Medium of instruction vital.
	Further research required.
Literature on "constructivist" mathematics teacher education.	Research on student teachers' teaching beliefs and performance. Research on factors affecting knowledge construction. Student teachers to elaborate change processes.
	Sustained support and guidance required for professional development.
Literature about learning in a Chinese setting	Requires research on Hong Kong Chinese learner characteristics.
Action research	
A powerful and easy to apply methodology to improve practices.	Employ Guba and Lincoln's (1989) criteria of credibility, dependability, transferability and confirmability.
Growing acceptance in mathematics teacher education.	Documentation of research and life histories of teachers and teacher educators.
Data collection	
Viability of various data collection methods.	Positive attitude and skills of the lecturer and student teachers paramount. Training essential.
	Search dissident students.
	Use of mother language vital.

Investigation on the factors which affect beliefs about teaching mathematics is appropriate. These factors include (1) the Chinese learner beliefs and disposition, (2) the learning environment created in HKIEd (including opportunities for group and class interactions, language employed for communication, sustained support and guidance from tutors, assessment practices), (3) the learning environment created in the schools where student teachers practise their teaching (including support and guidance from principals and teachers of the schools, inservice staff development of mentors in the schools, assessment practices of student teachers attached to schools), and (4) other factors affecting student teachers' knowledge construction (such as student teachers' negotiation skills).

CONCLUSION

The successful creation of a constructivist learning environment proved helpful in sustaining student teachers' social constructivist beliefs in their teaching approaches. My thesis adds to the paucity of literature on constructivist approaches, particularly in relation to secondary mathematics teacher education in a Chinese setting. Action research, the research methodology used and documented in this thesis, also provides higher institution teachers with a means to improve their teaching practices – an exercise which is still unpopular, as reported in the literature (e.g., Altrichter, 1997, p. 33).

After the teaching practice, the selected outstanding students exhibited and reflected (in the after-lesson discussions and in the end-of-term interviews) a change in their teaching beliefs – the teacher-centred orientation became more significant. According to findings in the end-of-module interviews, the school culture, the pupils and the teachers of the schools in which these students had their field experience are seemingly more "effective" in modifying beliefs than the "sustained" constructivist learning environment in my methodology classroom. More research studies are necessary to inform mathematics teacher education in the area of field experience.

It seems that an individual effort in a single methodology class can only have a minimal effect in prolonging student teachers' interests in using more interactive approaches in their future mathematics teaching. Isolated use of innovative strategies of teaching places limits on their effectiveness; more pupil-centred beliefs about teaching could perhaps be maintained by student teachers if they were immersed in a constructivist environment in every classroom in HKIEd throughout their course of study – a speculation yet to be investigated. Further research into these areas is necessary.

Continuous professional support is perhaps necessary for teachers and school principals, and has indeed been espoused in current government educational reforms in Hong Kong. The Education Commission (1997, p. 35) – an advisory body appointed by the government to give advice on the development of the Hong Kong education system – recommends that the government should devise a coherent pre-service and in-service training strategy for teachers in different educational sectors to cope with the changing needs of the school system and the teachers, and the future direction of HKIEd in achieving the objective is crucial.

The Education Commission further recommends that schools should also be encouraged to develop school-based training and collaboration (Education Commission, 1997, p. 36). I would recommend the formation of a learning community in every school setting so that teachers could learn from one another, take advantage of each others' ideas and gradually establish relevant contextual educational values for the benefit of their pupils. Heightened awareness and understanding of the importance of collegial collaboration and of common teaching rationales are necessary for effective curriculum changes and overall school development. Learning about mathematics teaching is a long-term holistic process that requires support from teacher educators and experienced practitioners in the field.

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Note: At the author's request, the Appendices (p. 318-497 of this thesis) have not been reproduced.

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